THE ENGINEERING RECORD
Published Weekly by the
McGraw Publishing Company
MAIN OFFICES:
114 Liberty Street, New York.
BRANCH OFFICES:
Philadelphia: Real Estate Trust Bldg.
Chicago: 1140 Monadnock Block.
Cleveland: Cuyahoga Building.
London Office: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES.

United States, Canada, Cuba and Mexico....$3.00 a year.
Foreign subscription .... $.00 a year.
25 shillings. 25 marks. 31 francs.
Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.

Changes in advertisements intended for a particular issue should reach the office of The Engineering Record on Friday of the previous week. New advertisements can be received up to noon of Wednesday of the week of issue.

NOTICE TO SUBSCRIBERS.

Remittances.—Remittances should be made by check, New York draft, or money order, in favor of The Engineering Record.

Changes of Address.—The old address should be given as well as the new, and notice should be received a week in advance of the desired change.

Back Copies.—No copies of issues prior to September, 1904, are kept on sale, except in bound volumes.

Date on Wrapper indicates the month at the end of which subscription expires. The sending of remittances for renewal prior to that date will be much appreciated by the publishers.

Club Rate.—In acknowledgment of assistance rendered by subscribers in the securing of new orders, a club rate of $2.50 per annum is quoted. This rate applies to subscriptions in clubs of two or more, at least half of the names in the club to be those of new subscribers.

Entered at the New York Post-Office as Second Class mail matter.

Copyright, 1906, by the McGraw Publishing Co.

Of this issue of THE ENGINEERING RECORD 12,000 *copies are printed. Total circulation for* 1906 *to date* 382,500 *copies, an average of* 12,750 *copies per week.*

TABLE OF LEADING ARTICLES.

A Great Railroad and Ocean Terminal........... 85
Plant for Important Construction Work.......... 85
Superheated Steam 86
Roads and Tires............................... 87
The Chalmette Docks of the New Orleans Terminal Co.—I. (Illustrated)......................... 88
The Jefferson Street Bridge, South Bend, Ind. (Illustrated) 91
Disinfection as a Means of Water Purification.... 94
The East River Tunnels for the New York City Terminus of the Pennsylvania, New York, and Long Island Railroad.—III. (Illustrated)....... 97
Report of the Board of Advisory Engineers of the Sewerage Commission of Baltimore.—I......... 101
Reconstruction of the Susquehanna River Bridge. (Illustrated) 105
A Large Multi-Cylinder Gas Engine.............. 107
A Long Steel Aqueduct for the Water Works System of Leeds, England....................... 107
The United States Express Company's Building, New York City. (Illustrated)................. 108
Speed Control of Hydraulic Turbines. (Illustrated). 111
Coal Tar Paint................................ 112

A Great Railroad and Ocean Terminal.

It may apparently be a misnomer to call the New Orleans Terminal Company's plant at Port Chalmette even partially an ocean terminal, yet it is a correct designation, in spite of the fact that it is located 90 miles from the mouth of the Mississippi River. Although it is designed to provide ample terminal facilities for a number of railroad systems centering at New Orleans, it is seven miles from that city. A complete description of the work and a full statement of its capacity will be found in this and the succeeding number of The Engineering Record; a reference to this description will show that it is truly an ocean terminal. Depth of water and docking space are provided for the greatest vessels seeking the port. A sfar as it partakes of the nature of an ocean port it is simply a protected harbor located at such a distance from the mouth of the river as the physical conditions of the latter and the commercial purposes to be served make most advisable. There is ample room for any amount of development of the business of the port, and it is easily and economically available for any increase of facilities that may ever be required.

There are features of its construction and of its general design as a railroad and ship terminal worthy of careful study. It is most interesting at the outset to observe that foreign study as well as experience in this country, particularly at the great port of New York, has led the designing engineers to a type of construction much the same as that which the Department of Docks of the city of New York has found to be so effective for its purpose. A massive masonry construction reaching down to bedrock or even founded upon piles cut off deep under water would have been most expensive anywhere in the vicinity of New Orleans. This type of dock construction was, therefore, rejected in favor of the much more economical but substantial pile construction, with the pier platform and freight shed constructed back of a comparatively light concrete retaining wall resting directly upon the tops of the piles cut off at about low water. At Port Chalmette there has been no attempt even to retain the earth back of the slip line under the large freight sheds, as it is allowed to take its natural slope under water among the piers.

One feature of the arrangement of these piers will not escape remark at first sight on the part of many engineers, although the character of the river doubtless justifies the arrangement adopted, and that is the inclination of the piers to the axis of the river. Inclined slips mean some loss of dockage space, which is important along a water front like that of Manhattan Island, New York, where the value of every square foot of ground counts substantially. At Port Chalmette, however, excessive cost of land does not exist, but the piers project into a silt-bearing river current. The latter condition demands such a position of piers as will enable the current to free the slips as much as possible of the sediment, or at least to prevent deposition as much as possible. There is also some gain in accessibility to the piers with a strong river current running across their heads. On the whole, therefore, there can be little doubt that the oblique position of the piers has been wisely chosen in this case, however much it might be criticised in such a place as the port of New York.

Inasmuch as Port Chalmette is to be a great place of exchange between railroad and ship freights, it is obvious that railroads must practically deliver directly to the ships or receive as directly from them with only space enough between to afford reception or temporary storage for classification, the freight floors being suitably commanded by convenient systems of power transfers. This is an obvious feature in an initial construction like that under consideration, but it is singular that at such a great shipping point as the city of New York, this class of accommodation is at a minimum of development.

The construction of the deep-water part of these great piers involved a number of features of deep pile driving of unusual interest, as the elevation of cut-off is at low water, meaning subaqueous operations for the greater part of the work. The vicinity of New Orleans and of all that part of the Gulf coast is remarkable for long and heavy pile driving. In the present instance there was an extraordinary number of piles to be driven, and largely with the aid of a follower guided by extension leads fitted to be raised or lowered as the exigencies of the work required. The plan of cutting off the piles at the proper elevation to receive the concrete bulkhead wall and the freight house superstructure was exceedingly simple, although not often employed. As the description indicates, a large diving bell formed what was practically an ordinary pneumatic working chamber under sufficient pressure of air to depress the water under the bell below the elevation of cut-off. It is obvious that the work of cutting off every pile in the lighted working chamber would have marked advantages and possess great convenience over the ordinary method of sawing under water. While the latter operation is commonly followed with reasonable success, there can be no question that the pneumatic working chamber will be found on the whole more satisfactory and effective, especially where there is a great number of piles.

On the whole, the features of this great terminal enterprise, as planned and executed, indicate the attainment of effective results with all the economy consistent with the substantial work.

Plant for Important Construction Work.

It will hardly be denied that even a difficult and elaborate engineering structure can generally be built by comparatively indifferent talent if unlimited time, money and life are expended, but in these days of vigorous competition and careful finance it is also a desideratum of the contractor to finish his work with the maximum despatch and the minimum expense or loss of life and these requirements have operated to make the contractor's field plant an elaborate and costly tool of immense power and flexibility. General methods have been introduced, work has been classified, certain features of practice have been virtually standardized, great attention has been paid to the utilization of scientific and mechanical principles and numerous special machines and appliances have been perfected, many of them interchangeably available for very different classes of construction work.

Both rapidity and economy are usually promoted by dividing very large engineering work into several sections each of which forms a separate contract, often distinguished from the rest by its peculiar conditions or requirements. Each contractor makes a study of the methods and equipment, often different from those of his neighbor, that will earn the largest dividend of profit on the work; that will accomplish it in the greatest safety, and that will involve the least outlay considering the amount of plant already on hand and the probable salvage at the end of the job or availability of the plant for future operations. In almost all cases this results in the installation of a plant that replaces hand labor by power wherever possible, provides for the regular sequence of operations so that no one of them is likely to be delayed by another, utilizes standard machinery and materials quickly available in the open market, provides specially for the prompt and continuous handling of materials, and to as large an extent as possible, particularly in recent years, aims to make the work independent of any special class of artisans. Such a plant operated by a well organized corps of engineers, superintendents and their assistants has become characteristic of most of the great contractors and construction engineers in this country, and many important contracts have been awarded, as in one case recently alluded to in these columns, over the heads of lower bidders, because the possession of a plant of this scope demonstrating the ability to execute emergency work promptly and inspired confidence in the engineers in charge.

Examples of the organization of contract forces and the equipments installed and methods followed for a wide variety of works of the first magnitude have been continually presented in these columns and include the Chicago Drainage

Canal, commenced about fifteen years ago, which was notable for the introduction of cableways, cantilever conveyors and hoisting apparatus of unusual magnitude for the handling of spoil, for the adaptation of channeling machines for cutting canal sides in rock, and for the establishment of many power plants from which steam and compressed air were distributed for considerable distances along the line of the work. For the building of the Titicus, Croton, Cross River and other recent important dams and reservoirs large steam and hydraulic motors were installed, extensive systems of surface tracks laid, batteries of powerful derricks and cableways were provided for the rapid and economical handling of materials and the engines for these machines together with pumps and other apparatus were operated from the central power stations. Costly auxiliary works and very long-span traveling cableways are now in operation for the improvements of the St. Mary River. The construction of the Rapid Transit Subway, New York, was notable for the number and variety of the ingenious methods devised for building it with minimum obstruction to the traffic in narrow streets, for the appliances used to support heavy traffic over excavations and for the distribution of power from central sources and the elimination of hand and horse labor.

The construction of deep foundations in difficult soils, particularly in New York and Chicago, has developed to a high degree the system of pneumatic caisson work, the machinery for providing the pressure, for handling huge weights rapidly and safely in the city streets and especially the multiplication of limited available working space in New York, while in Chicago, equally radical improvements have been made in the disposal of spoil, and in the construction of an underground system of freight tunnels which may almost be considered as a contractor's tool. In both these cities and elsewhere, work of great magnitude has been done in underpinning extremely tall and heavy structures and has required a considerable amount of hydraulic and pneumatic apparatus, special girders and sectional steel columns.

In the construction of the Brooklyn anchorage for the Manhattan bridge, a decided departure from ordinary contractor's equipment has been made in the operation of all the plant, both fixed and movable, by a costly and elaborate system of electric transmission, and the general tendency of important installations is largely to the transformation of steam power into electric, hydraulic or compressed air power which is easily transmitted to considerable distances without serious loss and greatly promotes the convenience and economy of operating individual tools.

Contractor's plant for bridge erection has been greatly perfected and extended and is characterized to-day by very powerful tools of the most special character, such as 60-ton steel derricks, 50-ton derrick cars, hydraulic and pneumatic rams for driving truss pins, the use of Z-shaped steel travelers of great height and of interchangeable steel falsework for the erection of long spans. Many special appliances have also been developed for the rapid and safe handling of bridge members, weighing up to over 100 tons, and in a number of cases large temporary spans have been built simply for use in the erection of the permanent spans.

Among the most important present installations of contractor's plant are those in New York, New Jersey and Long Island which have an aggregate value of much more than a million dollars, and are being operated for the construction of the Pennsylvania Railroad terminal stations and tunnels under the East and North Rivers. These plants have been provided by several contractors engaged on different sections of the work. One of them, described in a series of articles now appearing in these columns, is credited with what is considered to be the largest compressed air plant ever installed for such purposes and also includes on each side of the river large yards, equipped with extensive systems of tracks and derricks for hoisting and transporting material, apparatus for transferring and dumping spoil, a large quantity of improved plant for the economical product of steam and the transmission of power, hydraulic appliances of great power and immense shields and erecting machinery in the headings, besides inclined railroads and cable hauling for cars in the tunnel and on the surface and the installation of nearly one hundred pneumatic locks, some of them fitted with special safety appliances for the passage of men and materials in and out of the compressed air.

It is evident that the execution of important structures not only justifies but demands the installation of more and more costly and efficient contractor's plant and it follows that the best talent available will be employed in its design and operation and that the continued application of central power and special machinery to almost all of the contractor's operations will result in the still greater perfection of tools and appliances, the manufacture and improvement of which is to be to-day among the very important professional and commercial interests.

Under such conditions the work of the builder has within a few years advanced rapidly from a position, often in former times little more creditable than that of routine construction, to a standing to-day which ranks technically with that of the most eminent designers, and commanding the services of engineers of unexcelled ability, and requiring large amounts of capital and special appliances of great importance.

Superheated Steam.

Reference was recently made in these pages to the fact that while the use of superheated steam has been, for several generations of engineers, recognized as one of the pathways open for the improvement of the steam engine, yet the actual extent to which superheating enters as a factor into modern steam power plant practice is comparatively slight, and its influence seems disproportionately small having in view its apparent engineering possibilities. As this is a matter of special interest in these days of ever-increasing exactions along the line of economy, and of corresponding importance to engineers who are concerned with power plant design and operation, it is desirable to return again to the subject for its further consideration. In general, the reasons which have operated against a more general use of superheated steam group themselves into two chief classes: First, difficulties of a practical or operative character connected with the use of superheated steam, and as a result of which wear and tear and maintenance charges are increased to a marked degree. Second, a failure to appreciate fully the fundamental limitations surrounding the use of superheated steam, the conditions to be fulfilled in order to realize such benefits as may be properly expected, and the amount of improvement which may be fairly expected in any given case. The general character of the difficulties of the first class are perhaps more widely understood among engineers than the exact nature of the second group, and some features regarding these latter are worth noting in detail.

The improvement in economy from the use of superheated steam is not due, except in very small measure, to the mere fact of increase in temperature in the steam fed to the engine, or to the influence of such increase in temperature on what is commonly known as the thermodynamic or ideal efficiency of the engine. One of the erroneous views which has occasionally misled engineers is that the improvement in economy traces back to the familiar law of thermodynamics which expresses the economy of the ideal Carnot cycle in the form $(T_1 - T_2) \div T_1$, where T_1 and T_2 are the upper and lower temperatures of the isothermal paths along which all the heat is either received or rejected. Reasoning then that superheating means an elevation of temperature in the entering steam, it has seemed an easy step to ascribe the general improvement in economy to a corresponding direct increase in the ideal or thermodynamic efficiency of a superheated steam cycle. A moment's thought shows the error in this assumption. This formula quoted above refers to the Carnot cycle, and in which the heat given to the working substance is all communicated at the upper temperature, T_1, while in the case of superheated steam by far the larger part of the heat is communicated at the temperature of boiling, distinctly lower than the upper or superheat temperature, only a comparatively small part of the heat being communicated at the gradually increasing temperature due to the superheat condition. If, indeed, the steam could be expanded in a truly adiabatic manner and the remainder of the cycle could be carried out strictly according to the Carnot ideal, we should still fall far short of any such ideal economy as expressed in the formula $(T_1 - T_2) \div T_1$. In a typical case and in commercial terms, the conditions would be somewhat as follows: The heating of one pound of water from the lower temperature to that of boiling would mean the investment of about 230 B.t.u. at an ideal efficiency of about 14 per cent. The production of one pound of saturated steam would mean the further investment of about 860 B.t.u. at an ideal efficiency of about 28 per cent., while the superheating of this by 120° would mean the investment of some 66 B.t.u. at an ideal efficiency of some 32 per cent. The average working efficiency or earning power of this investment is seen to be, even in the ideal case, far below the 36 per cent., which would represent the value as given by the formula quoted above, where T_1 is the superheat temperature. In fact, the amount of heat involved in the operation of superheat is comparatively so small that it can have, so far as pure thermodynamic principles are concerned, but slight influence on the general efficiency of the cycle. The case is analogous to the man who invests, say, $2,500, at 3 per cent., $8,000 at 6 per cent., and perhaps $1,000 at 7 per cent. The average rate of interest in such case is but slightly raised by the 7 per cent. investment. It follows that expectations based on the direct application of the formula $(T_1 - T_2) \div T_1$, as in any way representing an ideal efficiency for the superheated steam cycle, are sure to be misleading, suggesting, if T_1 is used as the temperature of superheat, a gain far greater than experience can justify; and if the complete cycle is split up into its parts and the formula consistently applied, a gain entirely too small to warrant the necessary investment for equipment and the added expenses of maintenance.

Actually the gain comes, as has previously been stated in these columns, from an entirely different direction—in the case of reciprocating engines to which the present discussion more especially applies, from the suppression in varying degree of the loss due to cylinder condensation and involving the activity of a secondary or "cast-iron" cycle, as a result of which a considerable amount of heat may be shunted past the working cycle of the engine proper, and find its way to the condenser without having taken any active part in the work-producing cycle of the engine. The general nature of these operations within the steam engine cylinder is, of course, well known to engineers, and it is by reducing the readiness of transfer between the cast-iron and the working substance that the use of superheated steam may result in an improvement in economy. The improvement is due, therefore, not to the lifting of the ideal efficiency, but rather by a closer approach to the existing ideal which is fixed by the conditions of the case in hand.

Another caution may be given in connection with the common method of reporting steam engine trials. The results of such trials are very commonly given in pounds of steam per horsepower hour. The misleading character of this unit is too well known to need extended comment. The engine is not properly a steam engine, but rather a heat engine and the only consistent method of stating economy results must be in terms of heat expended per unit of power developed. From the very facts of the case statements of economy in terms of pounds of superheated steam per horse-power-hour are entirely misleading in comparison with similar results for an engine using saturated steam, and unduly favorable to the former. Thus, in the case of two engines using in one case, say, 13 lb. of saturated steam and in the other 12.5 lb. of superheated steam, the latter may in fact be the less economical of the two engines, a relation which would be at once shown by the expression of economy in terms of thermal units rather than pounds of steam. No definite meaning can therefore be attached to the report of a test of an engine using superheated steam in which the results are stated in pounds of steam per horse-power-hour, and the engineer who uses such results without transforming them into thermal units is sure to be misled at the very point which should supply him with accurate data for his guidance.

The following statements regarding the use of superheated steam can be readily derived from the principles of its action, as stated above:

First, superheated steam is more effective in saving with simple than with compound or multiple-stage engines, or conversely.

Second, with superheated steam there is less need for multiple-stage engines beyond the compound.

Third, superheated steam, in order to realize its full possibilities, should be carried in superheat to a point which will insure a superheated vapor throughout the admission and expansion stages of the cycle. With high-expansion ratios this will be difficult to realize completely, but the more nearly this condition is fulfilled the more effective the action in reducing the loss by cylinder condensation.

Fourth, superheating carried beyond this point will be of little additional value and will scarcely justify the additional expense.

Fifth, superheating should be carried to a higher degree as the expansion ratio is higher, and therefore to a higher degree for compound and multiple-stage engines than for a simple engine.

Sixth, a moderate degree of superheat is of comparatively small value, for the reason that the steam is quickly reduced by the operation of expansion, or even before, to the saturated or moist condition, with the resulting increase in the loss by the activity of the secondary or "cast-iron" cycle. While there is no sharp line, and while some gain will be derived from low degrees of superheat, such gains will hardly begin to be significant until a superheat of some 40 or 50° is realized, and from such point upward the gain will be continuous for further superheat until the approach of the limit mentioned under the third conclusion.

Seventh, superheating may be carried out in stages between the operations of expansion, as in the receiver of a compound engine, and in such case the sum of the partial superheats may be made less than when the entire operation is carried out at once, as in the usual arrangement.

The possibilities of the use of superheated steam, especially from the operative standpoint, have been far more carefully studied in Europe than in the United States, and the general subject of its proper adaptation to individual cases—both from the standpoint of operative conditions and underlying principles, as herein discussed—may be urged upon the engineers of this country as a topic well worthy of most careful examination.

Roads and Tires.

There are few problems of more pressing importance than those pertaining to the relation between roadways and vehicles under present conditions. In spite of all the inventive skill of the last century, the surfacing of roads has undergone relatively little change, and save for the rubber tire of the automobile, wheels are still wheels, and the newest truck shows little improvement over the quadriga of two thousand years ago. Vehicular traffic, notwithstanding the advent of railways and trams, has become steadily heavier, and the maintenance of roads is year by year a more formidable task. The automobile has brought with it very grave problems in maintenance as well as very serious conditions in the matter of tires. It is high time for improvements, but they do not seem to appear. As roads have been better graded and surfaced, they have brought on themselves elements of destruction in the increasing weights of load thus rendered possible. Wide tires which would serve as a partial remedy are very slow in coming into use. Legislation on the subject has accomplished something, although not yet any general improvement of practice to the extent necessary to save the roads.

Were it not for the rapidly increasing use of motor vehicles the direction to be taken by improvements would be fairly well determined. Thoroughly good macadam, when used by wide-tired vehicles, leaves little to be desired, save for the heaviest traffic. For this, carefully laid block pavement answers well, or in extreme cases, a steel roadway might be tried with good results. In fact, when wide, smooth and hard metallic tires are used the smoother and harder the surface of the wheelway the better. It would be of interest to see a steel trackway tried in a serious and practicable way on a considerable scale on streets through which a heavy freight traffic passes. The reports from oil or tar-treated macadam, too, are very encouraging for districts where traffic is less dense. When motor cars are considered, however, an entirely different condition of things is encountered. The wheels are no longer simply rolling elements, but driving wheels in which a certain amount of bite is absolutely necessary for traction purposes. To ensure this implies increased deterioration, either in the road surface, in the tires, or in both. As a matter of fact, a smooth and hard road surface would give adequate grip with rubber tires in dry weather, but wet rubber is exceedingly slippery, and to hold in all weathers a good bite on the road is required. Macadam fails very rapidly under these conditions, all the binding material being swept out as dust or mud; dirt roads suffer even more, and pavement is, of course, impracticable for very extensive use.

The possible results that may be reached by a cushioned wheel with a metallic tread, such as has been recently tried in various places, will be observed with interest. So far as they have come to the notice of this journal these results have not been altogether satisfactory. On rough roads there is serious lack of resiliency, but it is a question whether this objectionable feature exists with their use on smooth roads. If road construction kept in pace it would seem possible to get smooth running, even of heavy motor cars, without depending altogether on pneumatic tires, which are a constant source of trouble. In other words, why should not tires and roadbed be developed for each other, instead of trying to throw all the burden of accommodation on one or the other? As things now are, it falls heavily upon both, since the rubber tire grinds the road to its broken-stone basis and then grinds itself to bits. There is no need for the extreme adhesion thus provided unless the grades are such as ought not to exist on any properly located road. There is small excuse, either, for a 25-per cent. grade or for special appliances to enable a car to take it at high speed. Resilience in a roadbed is at present nearly out of the question, although it is not impossible to conceive improvements in this direction. The next best thing is a surface clear enough of gross irregularities to make a minimum instead of a maximum demand for resilience in the tires. It is a case for cooperative engineering skill to avert what is really a serious situation. Details like lightening the cars and giving them more clearance to prevent air-sweeping, will take care of themselves, and perhaps the growing scarcity of rubber may do the rest.

Notes and Comments.

Coal Mining by Open Stripping is extensively practiced in the Hazleton, Pa., district, where a number of seams of anthracite, from 25 to 40 ft. thick and of uniformly good quality, are found at depths of only 40 to 80 ft.

Direct Iron Castings from the blast furnace are being made to an increasing extent in England with excellent results. It is found that with the majority of ores the blast furnace iron approaches remarkably close in composition to the cupola iron, and thus permits high grade castings without remelting in the cupola.

Cylinder Cooling in the Alcohol Engine is considerably simplified as compared with cooling the cylinder of a gas or other type of internally fired engine by the fact that the flame of burning alcohol radiates heat less rapidly than that of gasolene or other internal-combustion fuels. Consequently less of the heat of combustion is communicated to the cylinder walls to be removed by the cooling jacket.

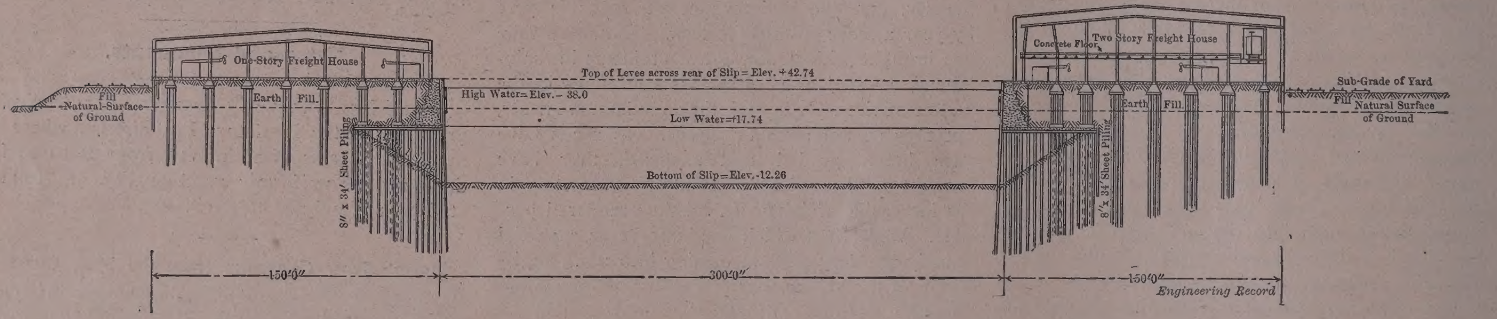
An Enclosed Steel Tube Incline for a blast furnace charging skip in use at the new furnace plant of the Federal Furnace Co. at East Side, Chicago, prevents the derailment of the skip car and also any danger or damage from falling material as often occurs with the usual bridge-type of double-skip hoist at blast furnaces. The tube is 7 ft. in diameter and has a 4-ft. gauge track carrying a 120-cu. ft. skip.

The Difficulty of Surveying Deep Bore Holes has been overcome by photography in South Africa, an apparatus devised by William Helme, of Johannesburg, having given accurate results in that not only the vertical drift of the hole, but also the position of the magnetic needle is recorded. The apparatus consists of a long brass cylinder which contains a small watch, a dry battery, two miniature electric lamps operating in connection with a compass supported on gimbal bearings, and a suspended plumb bob; at a predetermined time the watch makes a contact lighting the lamps, by means of which the positions of the plumb bob and the magnetic needle are photographed on a small disc of sensitized paper.

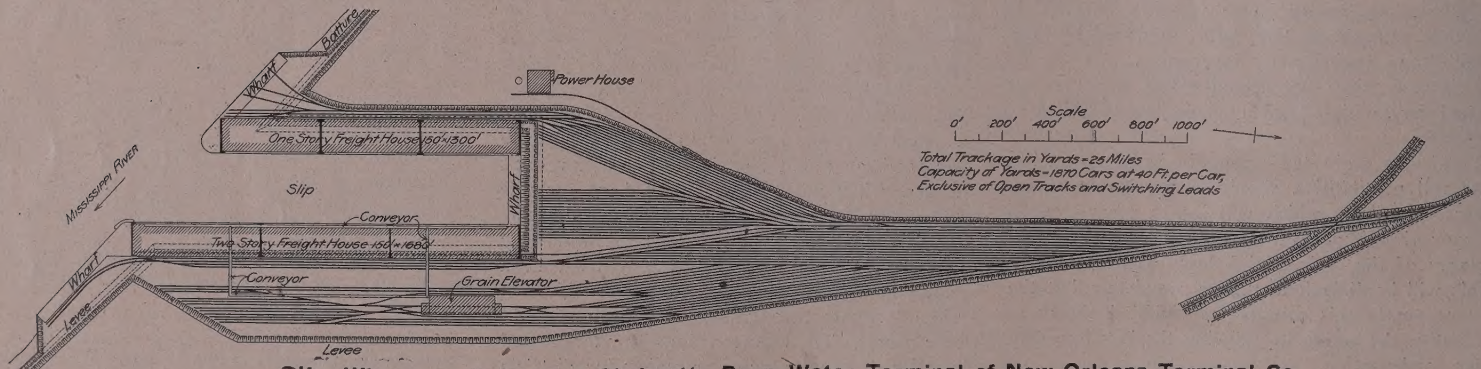
THE CHALMETTE DOCKS OF THE NEW ORLEANS TERMINAL CO.—I.

An Immense Deep-Water Terminal on the Mississippi River at New Orleans.

The New Orleans Terminal Co. has undertaken the development of an immense deep-water freight terminal on the Mississippi River at Port Chalmette, La., 7 miles below New Orleans and about 90 miles from the mouth of that river in the Gulf of Mexico. This terminal is being built according to a plan which has never before been attempted so far from tidewater in this country, or, perhaps, in any other country. Before deciding upon the final plans for the terminal an exhaustive study was made of similar work in this country and Europe, including a lengthy trip to England and the Continent by Captain J. F. Hinckley, chief engineer for the New Orleans Terminal Co., with Mr. J. C. Stewart, of the contracting firm of James Stewart & Co., of New York, who are executing the work under contract with the New Orleans Terminal Co., and Mr. A. L. Phillips, assistant chief engineer for the New Orleans Terminal Co. They visited almost all harbors in Europe where important docks have been built, or were then under construction, including the docks at Liverpool, Dover, Antwerp, Havre, the East India docks at London, the new docks at Belfast, Bremen, Hamburg, Amsterdam and Rotterdam, going fully into the plans and details of construction of the old works, as well as of the great docks and harbors under actual construction at the time of their visit. The design of the new docks in Europe differs greatly from that of the older ones, the principal difference being in the construction of the dock walls, which in the case of the old docks go down to the bed of the body of water along which they have been built, while in the newer docks these walls are supported on piles which are cut off below low water mark and capped with timber. As will be seen from the accompanying plans, the latter design was adopted for the dock at Chalmette.



Cross-Section of Slip and Fireproof Freight House.


Batture
Wharf
Power House
One Story Freight House 150′×1300′
Scale
0′ 200′ 400′ 600′ 800′ 1000′
Total Trackage in Yards = 25 Miles
Capacity of Yards = 1870 Cars at 40 Ft. per Car,
Exclusive of Open Tracks and Switching Leads
Mississippi River
Slip
Wharf
Conveyor
Two Story Freight House 150′×1680′
Wharf
Conveyor
Grain Elevator
Levee
Levee

Slip, Wharves and Yards of Chalmette Deep-Water Terminal of New Orleans Terminal Co.

The company for which the terminal is being built operates a belt railroad around New Orleans which intercepts all the railroads entering that city. The new terminal will when completed, however, handle chiefly the export and import traffic of the St. Louis & San Francisco and the Chicago & Eastern Illinois Railroads, and through them the same class of traffic from the entire Chicago, Rock Island & Pacific R. R. system, of which they are each a part. Traffic from the New Orleans & Northeastern R. R., over which the Southern R. R. has trackage rights, will also pass directly through the terminal, while traffic from other roads entering New Orleans will be handled through the terminal over the tracks of the New Orleans Terminal Co. The New Orleans Terminal Co. owns an area of 8.5 square miles, with a 2½ mile frontage on the river. The portion of the development of this frontage that is being carried to completion immediately includes a slip 300 ft. wide, which makes an angle of 49 deg. with the river, is 1,446 ft. long on the upstream, and 1,722 ft. long on the downstream side, and will have a uniform depth of 30 ft. of water at the minimum low water in the river; a 150 x 1,300-ft. one-story fireproof freight house on the upstream, and a 150 x 1,680-ft. two-story fireproof freight house on the downstream side of this slip; a railroad freight yard adjoining the slip, with a total of 25 miles of track and a capacity of approximately 1,900 cars, exclusive of open tracks and switching leads; a 2,000,000-bushel concrete fireproof grain elevator, and a power house large enough to contain sufficient electrical equipment to operate the entire terminal. Connecting wharves are also being built along the river front, one 584 ft. long on the upstream side, and one 560 ft. long on the downstream side of the slip. The total dockage facilities will thus have a length of 4,600 ft. A second slip of practically the same size as the one now being built will be constructed as soon as feasible after the present work has been completed.

The river is readily navigable, even at low water, up to and above the site of the new terminal by any vessel afloat. Directly in front of the terminal the depth of water reaches nearly 80 ft. at the middle of the stream. The river carries a large quantity of sediment at all seasons of the year, which quantity is greatly increased during floods. It has a current of from three to five miles an hour in front of the terminal. Whenever this current is reduced the heaviest part of the sediment which the stream carries is more or less readily deposited. In fact, during most of the year there is always a certain amount of silting taking place where the current is reduced by any cause. It is believed that the angle upstream at which the slip is built will greatly relieve the silting up of its channel; at the same time entrance to and departure from the slip with the strong current in the river will be made much easier than entering and leaving a slip at right angles to the river could be made.

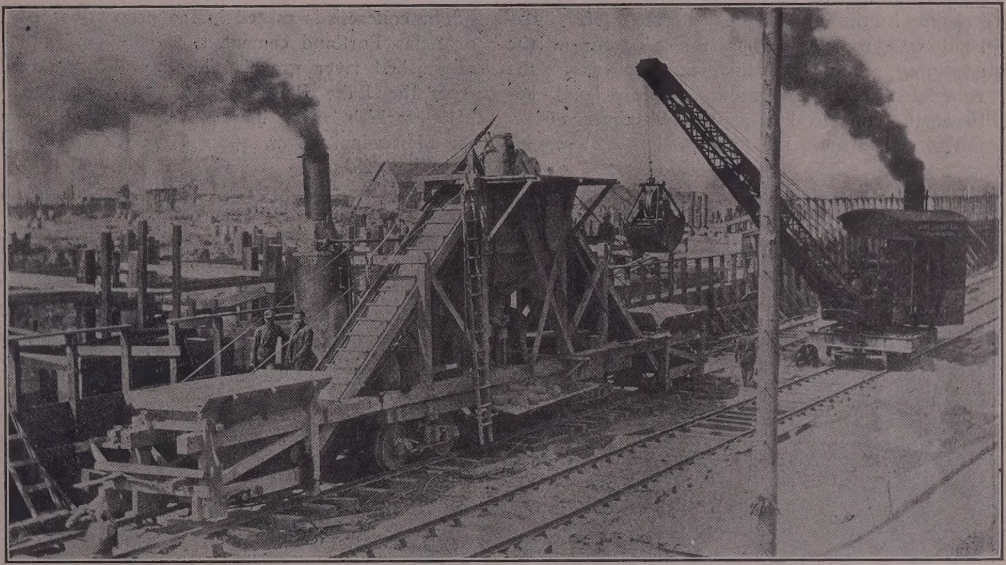
The natural surface of the ground at the site of the terminal is practically level, sloping very slightly away from the river. It is at Elevation 26.0, as referred to the mean water level in the Gulf of Mexico, low water level in the river in front of the terminal being at Elevation 17.74 and high water level at Elevation 38.0. The ground is protected from overflow during high water by a levee along the river bank, the crest of the levee being Elevation 42.72. As may be seen from the accompanying plan of the terminal, the slip and the wharves at the outer end of it extend some distance into the stream beyond the present levee along the river bank, in order to reach deep water in the river with the slip. The accompanying cross-section of the slip and freight houses shows the general arrangement and the type of construction that is being employed in building the terminal. Before the present levee is cut, as it necessarily will have to be, a levee will be built entirely around the site of the slip and connected with it.

The ground in the vicinity of the slip and, it is generally believed, much of the surrounding country is made up of material deposited from back water from the Mississippi River during overflows. The soil is peculiarly tenacious when confined, but much of it flows readily when wet if not confined. For that reason it may be well to explain briefly the type of construction employed in building the sea wall surrounding the slip, and the footings for the freight houses. A concrete retaining wall, 4 ft. wide on top, 24 ft. high, battered slightly on the front face and stepped on the back face to a width of 12.5 ft. at the bottom, is being built along the sides and the land end of the slip. The top of this wall is at the same elevation of the levee around the terminal, and the base of it is at low water in the river. The wall stands on a grillage of timbers laid on caps on piles. This grillage is 44 ft. wide and extends back under the freight houses, as shown in the cross-section. It is made up of 12x12-in. timbers placed ½ in. apart on transverse caps of 13 longitudinal rows of piles, 50 to 65 ft. long, the piles in the rows being 2 ft. 10¼ in. on centers. The two front longitudinal rows of the building footings stand on piles driven about 30 ft. below the natural ground surface. After the piling has been driven and the wall completed, an earth fill is made to bring the natural ground surface up to the level of the top of the levee. A row of 8-in. tongue and grooved sheet piling, 34 ft. long, is driven at the back edge of the grillage until its top is flush with the top of the grillage. When the excavation is made to form the slip it is expected that the material under the grillage will eventually take a slope of about 1 on 1½, as shown in the cross-section. The protection against the sliding of the fill under the freight house is believed to be fully assured by the concrete wall, the grillage and the row of vertical sheet piling.

The freight houses will be made as nearly fireproof as it is possible to construct them. They will have concrete floors built directly on the earth fill, and brick sidewalks, with reinforced-concrete roofs carried by structural steel columns fireproofed with concrete. Each house will be divided into three sections by a transverse firewall. A complete water-works system for fire protection will be provided and will be supplied with pressure from the central power plant. Three tracks will be laid along the land side of each freight house. Tracks are also extended to the wharves up and downstream along the river from the slip. The general arrangement of the main yards is too well shown to need explanation here. The position of the elevator shown on the accompanying plan is only tentative, and the details of the design of the elevator have not been fully developed as yet. The elevator will have, however, a conveyor belt system extending to the freight houses above their roofs, and thence the length of those houses, with which grain may be carried from the elevator to ships in the slip.

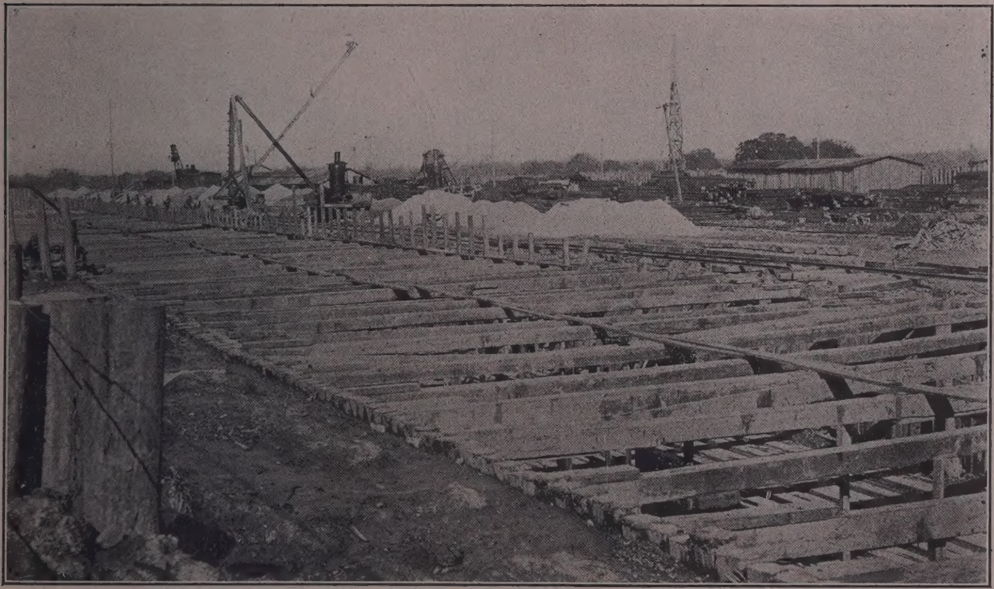
The magnitude of the work has necessitated the installation of a very large amount of contractors' plant in order that construction could be carried on in the proper manner. Two general methods of executing the work have been established. All of the work back of a line 90 ft. inside of the levee along the river is being done according to one general plan; the remainder of the work is mostly being done as underwater work. Of the portion of the work included in first general plan the piling, grillage and wall work on the north side of the slip has been finished. The piling on the south side of the slip has nearly all been driven, and work is being pushed rapidly on the grillage and concrete wall on that side. The piles have been driven and the grillage built on the remainder of the work that is outside of the levee and mostly under water.

The first work done on the north side of the site of the slip was to drive the piles which are to carry the footings for the roof columns of the freight house on that side. Three of these piles were driven for each footing in the five rear rows of footings, or 1,076 piles in all. These piles are from 35 to 45 ft. long and were driven until about 9 ft. of them remained above the natural ground surface. Three turntable land pile drivers, with 75, 85 and 100-ft. leads each fitted with a No. 1 Vulcan steam hammer, were used in driving the piles. At the same time this pile-driving work was in progress, a row of sheet piling was being driven on each side of the site of the grillage under the wall and the slip side of the freight house. The row of sheeting on the rear of the grillage consists of 8x12-in. timbers, 48 ft. long, which were driven about flush with the natural ground surface and are to be left in place when the work is completed. The sheeting was made tongue and grooved by nailing two 2x4-in. pieces on one 8-in. side and one 2x4-in. piece on the other 8-in. side of each timber. The single pieces were placed in the middle of the side of the timber and one of the 2x4-in. pieces flush with each edge of the timber so that the single piece on one timber fitted between the two pieces on the adjacent side of the adjoining timber.



Portable Concrete Mixing Plant.

The fill around the piles under the portion of the freight house back of the grillage was made with material excavated between the two rows of sheet piling. When the latter had been driven the excavation was started with a Hayward 1-yd. orange peel scoop bucket, handled by a guyed A-frame derrick mounted on a turntable platform and operated by a Lidgerwood hoisting engine. This excavator had a 55-ft. boom and was placed between the sheeting, working crab fashion on rollers. As soon as it had progressed sufficiently far, a second excavator of the same type was set upon a temporary platform over the front two longitudinal rows of piles which had already been driven. This second machine picked up the material excavated by the first machine and placed it around the piles already driven for the freight house columns.



Portion of Sheeted Trench on North Side of the Slip.

The excavation between the two rows of sheeting was carried to a depth of 15 ft. below the natural ground surface. Two waling pieces were nailed to each row of sheeting, above the bottom of the excavation and the two rows of sheeting braced against each other with timbers placed at proper intervals. When about 100 ft. of the trench had been opened the driving of the 13 rows of piles on which the grillage rests was commenced by one of the land driver outfits set on a trestle over the trench bracing. The piles were driven about flush with the bottom of the excavation. They were sawed off at the right level by hand, and then capped and the grillage timbers laid on them. The sawing and capping of the piles and the placing of the grillage could not be brought closer than 40 to 50 ft. from the pile driving owing to the bottom of the trench being raised as much as 3 ft. by the driving. The water in the trench was easily handled by one or two small pumps.

When the grillage had been completed, work was started on the forms for the concrete wall. The wall has 6 steps in its back face, each with a tread of 1 ft. 6 3/16 in. The bottom step has a rise of 3 ft. 1 in. and the remainder have a 4-ft. 2-in. rise. The wall forms were built up to one of these steps at a time. The trench braces were removed as the wall forms reached them, the sheeting at the front being braced against the completed wall and that along the rear by struts against the grillage. The wall was carried up in layers about 18 in. thick, and was built in alternate sections, 200 ft. long; that is, one section of the wall was built up to the top of one of the steps in its back face, then the same amount of concrete was laid in a third section, after which the section between the two was brought to the same level. A bulkhead with two 4x12-in. timbers nailed vertically to it, was placed at the end of each section so as to form grooves in the end of the concrete. This bulkhead was removed when the concrete in the adjoining section was laid, the grooves in the completed section forming a good bond between the concrete laid at different times.

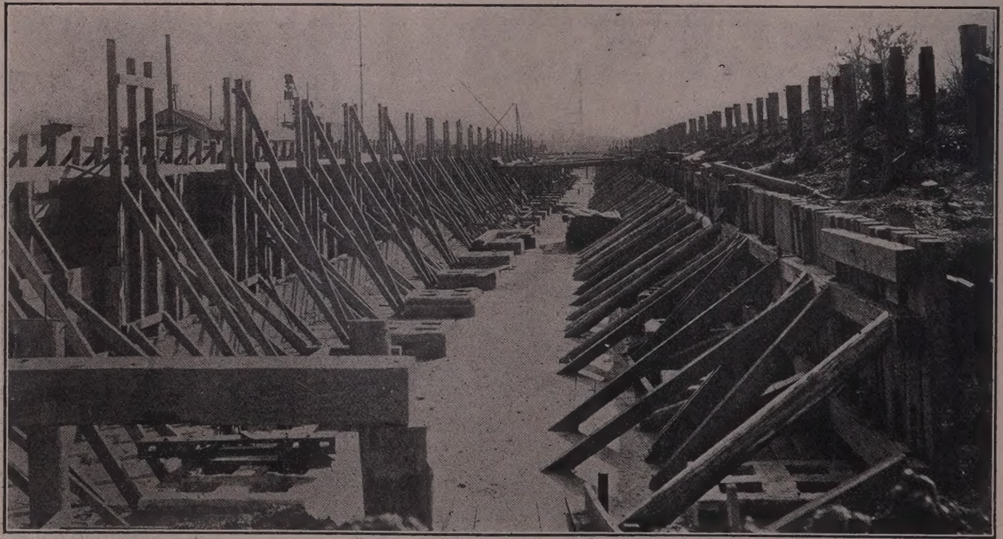
Completed Trench on the North Side of the Slip.

The wall around the present slips will require 42,000 cu. yd. of concrete to complete it. In order to handle and mix the concrete materials and to place the concrete economically a specially arranged concrete mixing plant was built and is being used. The general arrangement of the mixer is shown in one of the accompanying illustrations. Two standard-gauge tracks were laid on the natural ground surface on the slip side of the wall site. One of the tracks was just far enough from the wall so a car on it would safely clear the forms for the latter. The second track was about 15-ft. on centers from the first. The concrete mixing plant was built up on a 34-ft. standard-gauge flat car. Two 6x8-in. timbers, 58 ft. long, were laid longitudinally on the floor of the car. One of these timbers is on the outer edge of the car and the other 4 ft. from it, both timbers extending 12 ft. over each end of the car. A hopper, with a capacity of about 2 cu. yd. is carried at each end of the car by the cantilevered timbers. Sand and gravel are supplied from each of these hoppers to inclined belt conveyors which are built up to the middle of the car on a framework on the two longitudinal 6x8-in. timbers and discharges into a hopper 15 ft. above the floor of the car. Each of the hoppers supplying the belt conveyors has an under-cut gate which can be closed while the hoppers are being charged, or as desired. The belt conveyor from each end of the hopper extends horizontally under the latter. Each conveyor belt is 2 ft. wide and has a link-belt chain on each side. Between the two chain belts is a heavy double-thickness canvas belt carried by wrought-iron pipe cross pieces placed about 18 in. apart. Transverse overlapping seams, each one large enough to permit a pipe to be placed through it, are sewed in the canvas belt at such intervals as to cause pockets to be formed in the belt between the pipes which carry it when it is in place. The conveyors are driven by a 9x16-in. single cylinder steam engine mounted on one end of the flat car. The hopper into which the conveyor belts discharge has a capacity of about 3 cu. yd. and also has an under-cut gate. A ¾-cu. yd. Smith mixer is placed at the center of the flat car on the opposite side from the hopper and is supplied with sand and gravel from the latter. Cement is supplied to the mixer by hand from a small storage platform on the side of the flat car on which the bags of cement are placed from a box car on the adjoining track. Water is supplied to the mixer from a pipe laid along the wall and provided with hose connections at convenient intervals. A barrel is placed on top of the framework carrying the belt conveyors in order to insure an adequate supply for immediate use.

The concrete is mixed in the proportions of 1 of Atlas Portland cement, 2 of lake sand and 5 of washed river gravel. The sand is obtained from the Lake Pontchartrain or Lake Borgne, both brackish lakes. The gravel is dredged from the Mississippi River, about 80 miles above the work and brought down the river in scows. The scows are unloaded at the work into cars on an inclined trestle which extends from an unloading platform on the river side of the levee, over the latter and down on the temporary yards around the slip. The loaded cars of gravel are shunted back into the yards and finally reach a track along the track on which the mixer is in operation. The gravel is unloaded from the cars into storage piles along the mixer track.

During the first part of the work on the wall the mixing plant was operated on the track next to the wall. The gravel was handled from the storage piles along the tracks to the hoppers supplying the conveyor belts by a 1-yd. clamshell bucket handled by a locomotive hoist made by the Brown Engineering Co., of Cleveland, Ohio. The concrete was discharged by gravity from the mixer into the wall forms through a chute. The concrete mixing plant is shifted from place to place along the wall by the locomotive hoist. The wall was built up 4 ft. above the track with the mixing plant on the first track, the concrete being discharged from the mixer into the forms. The remainder of the wall was built with the mixing plant on the second track. The mixer discharged into 1-yd. steel buckets on a small flat car on a track between the two standard-gauge tracks. The buckets were handled from this car to the wall by a stiff-leg derrick mounted with its engine on a portable platform. This platform spanned the two standard-gauge tracks and had a traveler wheel at each corner running on the rails of the tracks. It was placed immediately in advance of the mixing plant and pulled itself and the latter along with a cable on a drum of the hoisting engine on it.

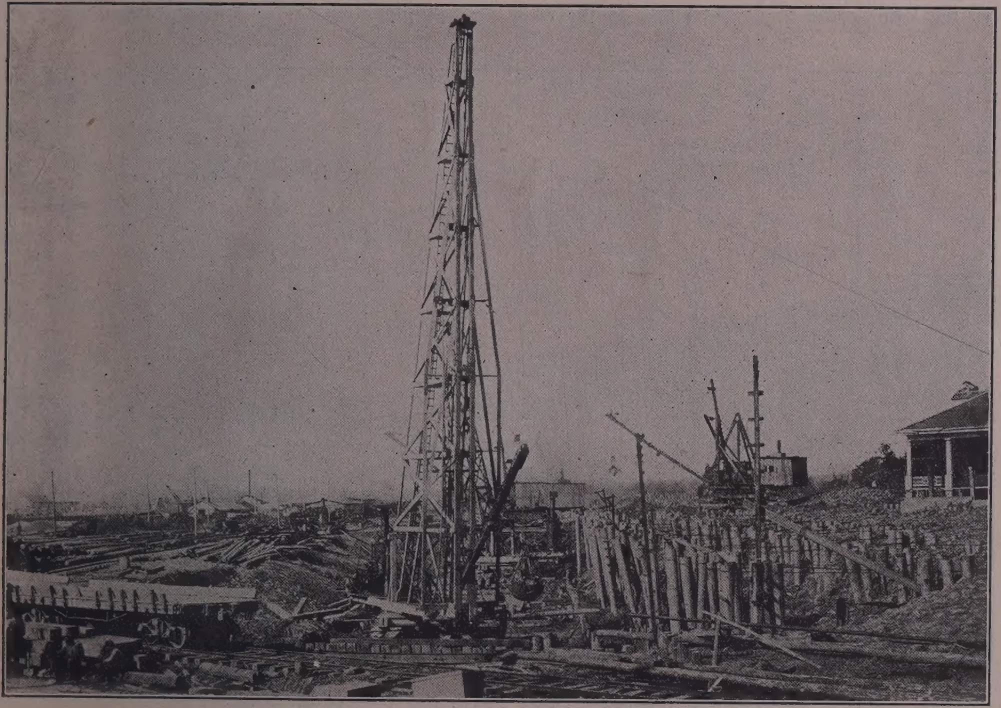
The mixing plant had a capacity of 275 cu. yd. a day, on the average. A number of features were developed in the operation of the plant and put into use. The hoppers at the ends of the car were each at first carried by a pair of small wheels. The jar on the hoppers from the sand and gravel dropped into them from the hoist bucket made the wheels impracticable, so they were removed and the hoppers blocked up from the rails of the track when the plant is in operation. Tie rods extending from both ends of each of the cantilevered timbers carrying the hoppers to the framework over the car relieve those timbers of a part of the load of the hoppers when the mixing plant is being moved. The hoist was used at first to fill both hoppers. It was found possible, however, to supply materials to the mixer from one hopper as fast as the mixer could handle them, so only one hopper was used, thus saving the labor of one man.



Looking Toward the River in Completed Trench on North Side.

The accompanying illustration showing a portion of the sheeted trench on the north side of slip is reproduced from a photograph taken before much of the concrete retaining wall along that side had been brought above the ground level. The storage piles of concrete materials may be seen just back of the trench. On the site of the slip are shown piles of timber used in the work and the repair and central power house sheds of the contractor. In the distant background to the right are the rows of piles driven to carry the two-story freight house on the south side of the slip. The reproduction of the photograph of the completed trench on the north side of the slip is somewhat the same view as the illustration just referred to, taken at a later date. It also shows on the left piles for the one-story freight house on the north side of the slip, and in the immediate foreground a portion of the partially completed retaining wall. The view looking toward the river in the completed trench on the north side of the slip shows the wall forms on the left, the completed bases for the building column footings in the trench and in the distance a pile driver at work just outside of the levee.

The work on the south side of the slip is being carried on somewhat differently from the methods followed on the north side. The piles for the freight house column footings not over the grillage were driven in very much the same manner as was followed in the work already described. The trench for the grillage was excavated, however, in an entirely different manner. A shallow layer of material is first removed with teams and scrapers and hauled up among the piles already driven. One of the turntable excavators fitted with a Hayward orange-peel bucket, follows the team work and excavates the trench to a depth of about 15 ft., or 3 ft. below the level at which the grillage timbers will be placed. The sides of the trench are not sheeted, but are allowed to assume whatever slope the material takes, which is about 1 on 1½. The material removed by the excavator in the trench is placed on the land side of the latter and then rehandled to place around the building piles by either of two similar excavators placed on temporary platforms over those piles.



Work in Progress on South Side of the Slip.

The permanent sheet piling along the land side of the grillage is driven with a pile driver in the trench as the latter has been brought to grade. Temporary sheet piling is also driven along the slip side of the site of the grillage when the bottom of the trench is reached in order to prevent any possibility of excessive sliding. The piling on which the grillage is to be placed is then driven. The two drivers working in the bottom of the trench drive as high as 100 piles a day. On the work on the grillage piles along the north side, where the drivers worked on timber braces between the rows of sheeting of the trench, following the piles down through the open excavation, 35 piles was a good day's work. The cost of the extra excavation required in the open trench on the south side does not approach the saving made in the cost of driving the piles in the trench over the cost of following them down in a sheeted trench.

The accompanying illustration of the work in progress on the south side of the slip shows one of the pile driver rigs in the immediate foreground temporarily engaged as an excavator. The piles for the rear part of the freight house and the excavators mounted on them are shown on the right. The storage piles and sheds of the contractors on the site of the slip are shown on the left of the trench. In the same illustration in the distant background to the left is shown the work in progress on the north wall and freight house footings. The pile-driver rig is in the trench for the grillage on which the dock wall and the footings of the two-story freight house are to be built.

The same concrete mixing plant that was used on the wall along the north side of the slip is being used in a similar manner in constructing the wall along the south side of the slip. A track is laid just back of the top of the sloping side of the trench that has been opened for the grillage under the south freight house. As this track has to be placed about 50 ft. from the center line of the wall, the concrete mixing plant is fitted with an additional belt conveyor which delivers the concrete from the mixer to the wall forms.

(To be continued.)

A TRANSPORTER BRIDGE is being erected over the River Usk at Newport, England, the design of which is that of an ordinary suspension bridge, with the girders placed at a sufficiently high level to permit shipping to pass under them. A line of rails is laid on both sides of the web of the bottom boom of each girder and on these rails a truck 104 ft. long, is operated. A platform, or car, 33 ft. long and 40 ft. wide, is suspended at the level of the river banks from this truck by 30 steel cables, which are crossed so as to form a trussing which prevents the car swinging either laterally or longitudinally. The car is designed to carry a live load of 66 tons, its own weight being 51 tons, making a total load of 117 tons on the suspended trusses. The truck carrying the car will be propelled by electric motors which are controlled from the moving car. The approximate cost of the bridge is $350,000.

Jefferson Street Bridge, South Bend, Ind.

A reinforced-concrete monumental arch bridge, having a total length of 554 ft., has recently been built to carry Jefferson St., in South Bend, Ind., over the St. Joseph River. South Bend is built on both banks of the St. Joseph River, and Jefferson St. is one of the principal thoroughfares connecting the two portions of the city. The river has a clear width of nearly 500 ft. at the crossing and is at an angle of 60 deg. with the center line of Jefferson St. The dam of a hydro-electric power development, a short distance below the site of the bridge, forms a mill pond, with a practically uniform stage of water, for about four miles above the Jefferson St. crossing. A city park has been developed along one bank of the river, upstream from Jefferson St. The bridge is designed according to the Melan system of arch reinforcement and has been treated architectually to conform with the unusually prominent position that it occupies. It has four 110-ft. elliptical arch spans, which had to be built on a 60-deg. skew with the river, and carries a 52-ft. roadway, with a 10-ft. walk on each side. Special attention has been devoted to the design and treatment of the copings and balustrades on the spandrel walls on each side of the bridge, and to that of heavy corbels, with half columns and heavy capitals, corbeled out from both ends of each pier.

The roadway on the bridge is on a 1.3 per cent. grade, which grade, together with the extreme skew on which the piers and arches had to be built, greatly complicated the design and architectural treatment, as well as the construction. The nose ends of the piers are continued beyond the sides of the bridge on the same skew with the longitudinal center line of the latter that the main portion of the piers make with that line. They have round ends and a heavy capstone of concrete. The corbel is normal to the pier, while its column and capital on each end of the pier are normal to the sides of the bridge. The four spans of the bridge have a rise of 11, 12.6, 14.25 and 15.85 ft., respectively, the springing lines of all four spans being at the same elevation. The unbalanced appearance that would be expected to result from the difference in elevation of the tops of spandrel walls above the springing lines of the arches is practically all relieved by the treatment of the corbels on the ends of the piers.

The capitals of the corbels carry small semi-circular balconies which are outside the walks along the sides of the roadway on the bridge and have the same balustrade around them that is built on the top of the spandrel walls. The pier at the middle of the bridge is considerably heavier than the other two piers. The corbel on each end of this pier is also heavier than those on the ends of the other two piers, the tendency being to balance the appearance of the structure, although one end of it is considerably higher above the water than the other. The difference in elevation between the tops of the spandrel walls and the capstones on the different piers is taken up in the column portion of the corbel in such a manner that the varying height of the bridge is scarcely noticeable from the side. The faces of the spandrel walls have panels, 6 in. deep, cast in them, one panel over the haunch of each arch. These panels are given what is, perhaps, an unusual depth in order to secure a true panel effect in the plain, smooth face of the spandrel wall.

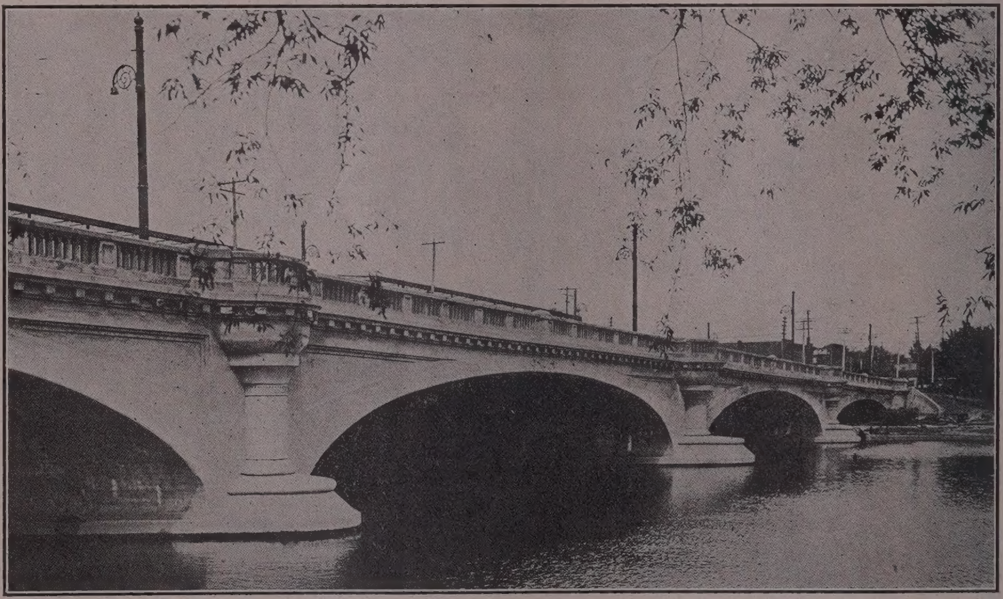
The three piers of the bridge have a uniform height of 19 ft. 7 in., with their tops at the same elevation, 1 ft. above the crest of flash boards on the dam below the bridge. They are built on piles cut off 17 ft. below low water level in the stream. The springing lines of the arches are at the tops of the capstones on the piers. The arch rings are nearly true ellipses, having seven centers. Each arch ring is reinforced with 25 longitudinal steel arch ribs, spaced 35 in. apart on centers. These ribs are of the typical pattern used in the Melan arch as designed by the Concrete Steel Engineering Co., of New York. The theory of the design and the details of this type of arch reinforcement have been fully described in previous articles in this journal, so this description will not be repeated here, although rather comprehensive illustrations of the details of the balustrades, corbels and copings are reproduced herewith. The arch rings have a thickness of 27, 28, 29 and 30 in. respectively, starting with the arch of greatest rise.

The spandrel walls are 18 in. thick at the top, have vertical front faces and are battered on the rear face, the base being 40 per cent. of the height. Each spandrel wall is anchored to its arch ring by ¾-in. Johnson corrugated bars, placed 24 in. apart on centers, 6 in. inside the rear face of the wall and parallel with that face. Four expansion points are placed in the spandrel wall on each side of each arch; two of these joints are on each side of the transverse center line of the arch, at about the fifth points. The corbel on both ends of each pier is securely anchored to the arch ring, the capstone of the pier and the spandrel wall with steel reinforcement. Two built up Z-bars anchor each capital in place. One of these Z-bars is placed on each side of the center line of the capital with one leg in the latter, and the other in the arch ring, as shown in the accompanying cross-section of the pier corbel. Each of these capitals is also anchored to the pier by fourteen ¾-in. Johnson corrugated bars, which are spaced around a semicircumference and extend down through the column into the concrete of the pier.

A cornice is corbeled out from the face of the spandrel wall at the top, the details of which are shown in one of the illustrations. Dentils, 10 in. square on the face, are placed 2½ ft. apart on centers along the under side of this cornice. Each of these dentils is anchored to the spandrel wall by two ¾-in. Johnson corrugated bars. A balustrade, 3.5 ft. high, is placed along each side of the bridge over the spandrel wall. The details of this balustrade are also shown in one of the illustration. The copings on the parapet walls and the base were built in place. The tops of the balustrade were cast in 8 ft. 4 in. lengths in metal forms and put in position after the concrete in them had been cured. Each baluster was also cast in a metal form and cured before being put in place. The posts over the piers were built in place. The 8 ft. 4 in. lengths of the base and copings of the balustrades are dovetailed together by projections and insets on the ends of the lengths. Each baluster is also keyed at the top and bottom into a groove in the top of the base and another groove in the under side of the copings. The uniform results obtained in casting the pieces of the balustrade and the successful manner in which the unusually large amount of detail was brought out in the construction is quite clearly shown in the accompanying reproductions of photographs of the finished bridge.

The concrete in the bridge was made in several proportions depending on the location it was to occupy, Universal Portland cement being used exclusively. The concrete in the piers, abutments and wing walls was mixed in the proportions of 1 part cement, 3 parts sand and 7 parts gravel. For the arches between skewbacks and for the pedestals, balustrades and parapet walls the concrete was mixed in the proportions of 1 part cement, 2 parts sand and 4 parts gravel. For the spandrel walls, it was made 1 part cement, 3 parts sand and 6 parts gravel. The volumes of sand and gravel in the mixtures of concrete were measured loose. The concrete was mixed in a 1-yd. Smith mixer, and was generally made moderately wet.

Construction.—Jefferson St. was formerly carried over the river at this crossing on a steel bridge having three 168-ft. through Whipple spans. This bridge had a 24-ft. roadway, with a 6-ft. walk on each side, and carried a single track of a street railway. It had to be moved downstream a short distance and placed on temporary piers, so that it could be used to carry traffic during the construction of the concrete bridge. The spans of this steel bridge weigh between 120 and 135 tons each and were moved on barges without being torn down. The abutment at one end of the bridge was about 60 ft. from the edge of the water. The river end of the span at this end of the bridge was floated downstream on a barge. A trestle was built up on the shore along the path the land end of the span had to follow and four 60-lb. railroad rails laid on ties on this trestle. Heavy steel plates with flanges were then attached to the under side of the bridge shoes on that end of the span so the latter could be hauled along on the rails without any danger of leaving the track. The other two spans were both floated downstream with a barge under each end.



The Completed Bridge From the Upstream Side.

The two barges used in moving the spans were 20 ft. wide, 70 ft. long and 4.5 ft. deep. Two barges were required in building the new bridge, the usual size of barge for such work being 18 or 20 by 50 ft. By making these barges a little larger than required in the construction work, they could be used for moving the spans of the old bridge and then in the erection of the new structure. The barges had solid gunwales and three solid longitudinal bulkheads and were built of 4-in. plank, drift-bolted together. Six transverse bulkheads of two rows of ¾-in. tongue and grooved plank with tar paper between the rows, were built transversely across the hold of each barge, forming 28 separate compartments, about 5 x 10 ft. in plan. In this manner the water was prevented from rushing from one end to the other of the hold when the barge was slightly listed by unequal loading, and in case of a leak only one compartment would be filled with water.

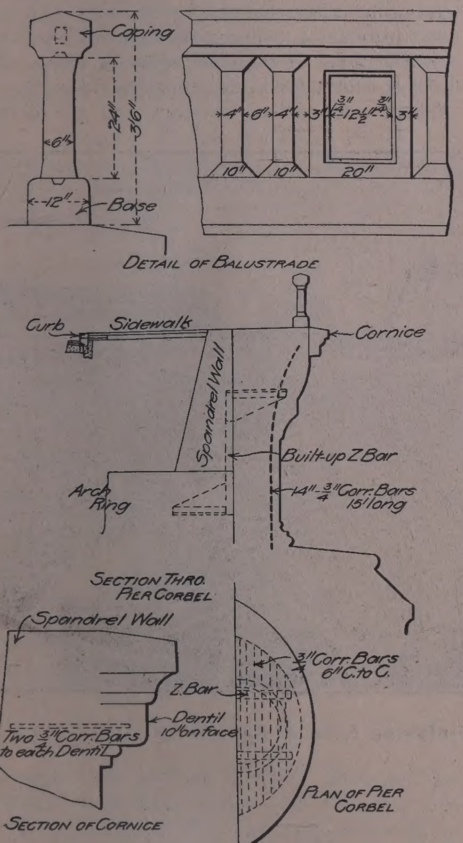
Four piles were driven upstream for anchorages for the hauling lines used in moving the bridge. A windlass was mounted on each end of both barges and a hawser fastened to these piles and piles downstream from the bridge was hitched around each of these windlasses. The land end of the span was pulled along on the rails on the trestle instead of being placed on rollers, in order to prevent any possibility of the movement of the end of the span becoming uncontrollable in case an accident occurred while the span was being moved.

Each span was carried directly while being moved on timber cribbing built up on the deck of the barges, one barge being toward each end of the span. The barges were loaded with water ballast before the cribbing was erected. When everything had been made ready enough of the water ballast was pumped out of the two barges to lift the span from the bridge seats; then the span was floated to its new location on the temporary piers and lowered into position on the latter. The span, which was shifted with one end on a barge and the other end dragging on the rails on the trestle, was moved to the new location, 72 ft. downstream, in 3 hr. The middle span was floated to the new location in 2 hr. and the span at the other end of the bridge in 15 min.

The old bridge is at present carried on temporary pile-bent piers. The spans of this bridge were built on about the same skew as the arches of the concrete bridge have been built. The steel bridge is to be torn down and erected again 2 miles upstream. At the new location the crossing is nearly at right angles with the river. The masonry piers which will carry the old skew spans were built parallel with the channel of the stream in order that they may be used for straight spans when the old superstructure is replaced. A special form of bridge seat has been adopted on these piers so the old skew bridge spans could be placed on them. Two 24-in. I-beams were placed on top of each pier at the angle of the ends of the old spans. Both ends of these 24-in. beams cantilever out over the sides of the piers. Two 15-in. I-beams were built flush in the top of each pier, one under each end of the pair of 24-in. I-beams. One end of these 15-in. beams is anchored in the concrete; the other end extends out under the cantilevered ends of the 24-in. beams to prevent the latter from buckling. With this arrangement the old skew spans can be readily used on the straight piers.

The main thing to be decided after the old bridge had been moved from the site of the concrete bridge was the location of the concrete mixing plant. The economical location of this plant was largely determined by the facility with which concrete could be handled from it to the two abutments and the three piers, since a large percentage of the concrete is contained in the piers and abutments. Owing to the uniform stage of the river at the site and to a favorable location for the mixing plant, the arrangement of cableways spanning the site longitudinally that has been followed in constructing a number of bridges of this type, was not adopted.

The mixing plant was placed at one side of the abutment on the park side of the stream. At the point selected the ground drops away, so that the mixer could be set at one elevation and the storage piles of gravel and sand on the slope above it, in such a manner that they were at about the level of the charging hopper of the mixer. A trestle was built up at this latter level and extended from the mixer to the storage piles of sand and gravel. The sand and gravel were hauled to the mixer in side dump cars on a track on the trestle. The cement was stored in a house on the other side of the mixer at the same level as the trestle. A guyed derrick, with a 60-ft. boom and a bull wheel, was set up on the river side of the site of the abutment close to the mixing plant. The material from the excavation for this abutment, including the removal of the stone masonry abutment of the old bridge, was handled in skips by this derrick. The concrete for the abutment was also handled in skips directly from the mixer to position by the derrick.



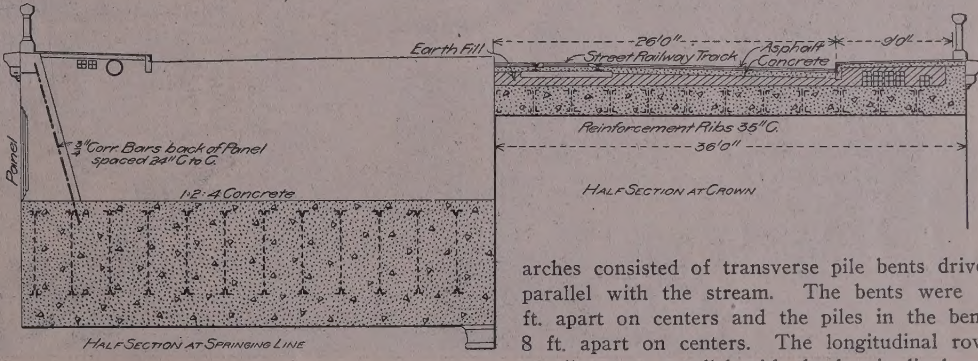
Details of Design.

The excavations for the three piers were all made in cofferdams. The concrete for the piers was also placed in these cofferdams. The river bed at the side of the bridge is sand and gravel overlying clay, the depth of water being 5 to 14 ft. The sides and ends of the cofferdam consisted of one row of Wakefield sheet piling, which was driven by a pile driver on one of the barges, a hydraulic jet being used in conjunction with the driver. As the piles on which the piers are built were cut off at 17 ft. below low water level, the excavations in the cofferdams had to be carried 2 ft. below that depth. The excavations were made with an orange-peel bucket handled by a derrick mounted on one of the barges. The regular pile driver leads were built extra wide and carried a pair of extension leads, which could be lowered into the excavation so the piles in the cofferdams could be driven with the same driver used on the other work, without a follower.

The concrete work was carried forward consecutively from the abutment adjacent to the mixing plant. After that abutment and the pier next to it had been brought up to the springing line of the arches, the centering was erected for the first arch and the arch ring built. The other piers and arches were then built in regular succession. A trestle was built across the river about 20 ft. upstream from the bridge site. A standard-gauge track was laid on this trestle, level with the floor on which the mixer discharged. The concrete for the piers and the other abutment was hauled out on this track in bottom-dump push cars. These cars were run out over the piers on branch tracks from the trestle, and the concrete dumped directly in place. The derrick used on the first abutment was afterwards set up on the land side of the other abutment. It handled the material from the excavation for this latter abutment, including the old masonry abutment, and also handled the concrete for the abutment by raising the bodies of the bottom-dump cars and swinging them to any point desired.

The concrete for the portion of the bridge above the springing lines of the arches was largely hauled out from the mixer on a track on a trestle between the first trestle and the upstream side of the bridge. This second trestle was built on an incline up to the transverse center line of the first pier. The track was then extended across this pier until the concrete in the arch between the latter and the first abutment built had been placed. The concrete in portion of the arch over the skewback was hauled up the incline and then on the branch track over the pier in the same bottom-dump cars used in placing the concrete of the piers. The concrete for the remainder of the arch ring was hauled from the mixer to place in two-wheeled bottom-dump steel carts, with a capacity of about ¾ cu. yd. Two of the loaded carts were placed on a flat car at the mixer and then pulled up the incline to the branch track over the pier by an electrically driven hoist.

The arch rings were built in longitudinal sections which were generally wide enough to include three of the reinforcement ribs. A runway was laid over the section on which work was in progress, extending toward the mixing plant from the branch track over the pier. This runway was blocked up above the top of the arch ring and was laid so the concrete could be discharged from the bottom-dump carts into place. The empty carts were run back to the mixer over the finished work by hand. When the first arch and its spandrel walls had been finished, the track was extended to the next pier and the next arch built in the same manner; then the third and fourth arches from that end were built in succession.


Earth Fill
26'0"
9'0"
Street Railway Track
Asphalt
Concrete
Reinforcement Ribs 35" C.
36'0"
Panel
3/4" Corr. Bars back of Panel spaced 24" C. to C.
1:2:4 Concrete
Half Section at Crown
Half Section at Springing Line

Cross-Sections of Arch Ring.

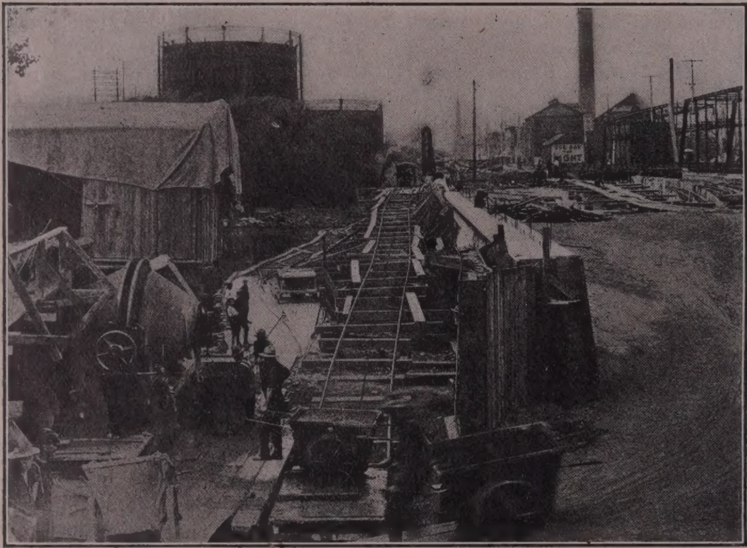
The longitudinal sections in which the arch rings were built were on a skew with the abutments and the piers. The bearing of these sections on the piers was such that no provision had to be made for this condition in placing the concrete over the piers. The rear portion of each abutment, however, was carried up to the plane of the top of the skewback at that point with a toothed vertical front face. This toothing was made in such a way that the end of each of the sections in which the arch ring was built had a bearing on the abutment normal to the longitudinal center line of the section. The longitudinal sections were laid consecutively across each arch. The outside reinforcement ribs in each section were tied to the outside ribs in the adjoining section by steel straps about 10 ft. apart on centers. As the concrete was carried up in the forms along all exposed faces of the arches, spandrel and wing walls a 1-in. layer of 1 to 2½ mortar facing was placed next to the forms and brought up with it. The lagging of the spandrel wall forms was also coated with soap before the concrete was laid in them. After the forms had been removed the exposed faces were rubbed down with a piece of soft pine to remove the surface film and any effervescence that had occurred.

The falsework carrying the centering of the arches consisted of transverse pile bents driven parallel with the stream. The bents were 12 ft. apart on centers and the piles in the bents 8 ft. apart on centers. The longitudinal rows of piles were parallel with the longitudinal center line of the bridge. The transverse bents were capped with 4x12-in. plank. An 8x12-in. stringer was blocked up on each pile cap with wedges. The joists of the centering were carried by these stringers. These joists consisted of 2x12-in. plank, which were cut in a planing mill to the true lines of the arch and were placed 11 to 12 in. apart on centers. The lagging for the arch rings consisted of ¾-in. plank dressed on one side and both edges. The lagging for the remainder of the forming was 2-in. plank, except in the forming for the trimming on the sides of the bridge, where special work had to be done.

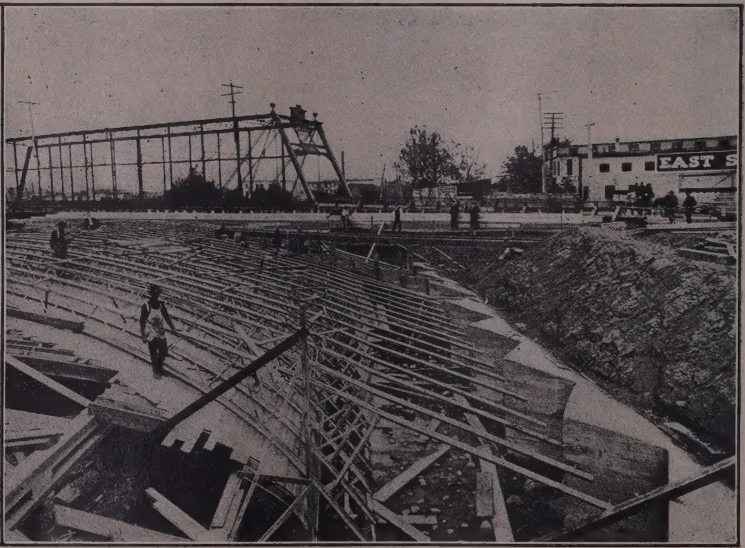
After the completion of arches and spandrel walls, the top surface of the arches, piers and abutments and the inner surface of the spandrel walls were given a heavy coat of neat cement grout. When this had set it was coated with coal-tar pitch. The spandrel fill was then made with sand and gravel that had been removed from the excavations for the abutments and piers. This filling is drained by four 2-in. wrought-iron pipes at each pier. These pipes are placed 15 ft. apart across the bridge and extend from the space over the pier near the springing line to 3 in. below the soffit of the arch. The surface of the concrete over the piers is formed to drain to these pipes. The line of drainage is covered with a layer of coarse gravel, and the top of the pipes is covered with a metal screen.

A 9-in. steel channel, anchored in the concrete of the walks on the bridge forms the face of the curb along each side of the roadway. Openings are made in this channel on both sides of the roadway at the center of each arch, to provide outlets for the drainage from the roadway. A 6-in. sewer pipe extends from an inlet at each of these openings down through the spandrel fill and through the concrete arch ring. The roadway is paved with asphalt which is laid on a 6-in. concrete base on the spandrel fill. The bridge carries two street railway tracks. A number of conduits for electric wires, a 16-in. gas main and a 12-in. water main are laid under the sidewalks.

The funds for building the bridge were provided by St. Joseph County, in which South Bend is located, but the structure will be maintained by the city. The bridge was designed by Mr. A. J. Hammond, as consulting engineer for the board of county commissioners, and was built under his direction. The Concrete Steel Engineering Co., of New York, acted in a consulting capacity to Mr. Hammond in connection with the reinforcement. The bridge was built by Mr. James O. Heyworth, general contractor, of Chicago, Mr. O. E. Strehlow being in immediate charge of the construction. The contract price for the bridge, complete, was $128,875. The old steel bridge was also moved downstream and set on the temporary pile piers by Mr. Heyworth, the contract price for this work being $7,000.



Arrangement of Concrete Mixing Plant.



Method of Finishing Face of Abutments.

An Interesting Motor-Driven Mine Ventilating Plant has recently been installed in Northberg pit at Eschweiler-Aue, Germany, in which novel methods of variable-speed control are resorted to in connection with alternating-current operation of the motors. The blower has a 9-ft. wheel, 4½-ft. face, and takes suction axially on either side and discharges upward through a delivery casing of concrete, 7x9 ft. in section. It has a normal discharge of 70,000 cu. ft. per minute at 300 r.p.m. upon a consumption of 800 h.-p. and a maximum duty of over 90,000 cu. ft. per minute at 370 r.p.m. and 136 h.-p. Power is delivered by a 5,500-volt alternating-current and, to provide for variable speed operation of the fan, it is connected to two 80-h.-p. asynchronous motors, one at either end of its shaft, which work in parallel at the higher speeds, but for the lower speeds have a 16-h.-p. synchronous motor coupled direct to one of them in which the rotor currents are passed instead of into resistances, the motor thus returning, restoring to the shaft energy that would otherwise be lost.

Disinfection as a Means of Water Purification.

A paper read before the American Water Works Association by Mr. George C. Whipple.

There is a growing feeling on the part of some sanitary engineers and chemists that disinfection of water and sewage by the use of chemicals is destined to be a matter of some importance in the future. The idea of adding poisonous chemicals to water for the purpose of improving its quality for drinking purposes has generally been considered as illogical and unsafe, and unfortunately most of the substances which have the power of disinfecting are poisonous to a greater or less extent. An indiscriminate condemnation of the use of chemicals, however, would be unjust. Already the use of alum in connection with mechanical filtration has become well established, and experience in scores of cities has shown that it produces no ill effect on the quality of the water treated. This is also true of lime, soda ash, sulphate of iron, and other chemicals similarly employed. The use of copper sulphate, about which so much has been heard of late, has not been attended with the unfortunate physiological results predicted by some, even though its use has not always accomplished all that was expected of it. Ozone has already been employed in a number of instances with satisfactory sanitary results, and even compounds of chlorine have been used with apparent success in a number of places. There is need, therefore, of reconsidering some of the old views regarding the use of disinfectants, and of investigating them carefully to find what are their practical dangers, their merits, and their cost. Almost every sanitary engineer has at one time or another been confronted with conditions where he would have gladly availed himself of the temporary use of a disinfectant for water if he had known of one on which he could have relied and which could have been used without danger, or even with less danger than that to be feared from infected water.

Recently some of the English chemists have been giving their attention to the study of chlorine, while the use of ozone has been the subject of many experimental researches both in Europe and America.

The writer has no comments to offer at this time on the general subject, as he believes existing data are too meagre for forming an intelligent opinion. He wishes merely to call attention to the need of a more thorough study of the subject and to describe two water-works in Belgium which he visited recently where chlorine is used as a disinfecting adjunct to filtration—namely, at Ostende and Middelkerke.

Ostende is one of Belgium's most famous seashore resorts. The king has his summer palace there. The population at the height of the season reaches 70,000, but during the winter it is only half as much. The country is flat and the only available water supply sources are the canals and some small sluggish streams. All of the water is more or less brackish. The city supply is taken from the Bruges-Ostende canal, a little way above the town. It is turbid (turbidly estimated as 50), slightly brackish to the taste, hard and open to pollution from many sources. The water consumption is said to be about 1,000,000 gal. per day during the summer.

The system consists of a pumping station, a settling basin, a battery of 10 mechanical filters, a disinfecting outfit a small glass-covered sterilizing chamber, an open pure-water basin, and a standpipe. The mechanical filters are of the Howatson type, which are more or less commonly used in Belgium and France for water-purification, for water-softening and for sewage treatment. They consist of steel tanks with the usual features of strainers, sand stirrers, etc., and resemble some of the older types of filters sold by filter companies in this country. They are of lighter construction, however, and the devices for controlling the flow, applying the coagulant, etc., are much less perfect than those familiar to American engineers. As a clarifying agent the filter plant at Ostende seemed to be giving local satisfaction using a small amount of alum. It does not pretend to give a high bacterial efficiency.

The novel feature of the Ostende plant is its method of disinfection, which is accomplished by the use of peroxide of chlorine prepared by a method devised by Dr. Maurice Duyk, chemist to the Minister of Finance and Public Works, Belgium. This substance is made at the works from potassium chlorate and oxalic acid. A mixture of these two salts in crystalline form is put into earthen trays about 1 ft. in diameter, resembling the saucers used under flower-pots. About 4 lb. of potassium chlorate and 6 lb. of oxalic acid constitute a single charge. This is moistened with a little water and put into a chamber kept at a constant temperature of 40° Cent. This chamber looks like the ordinary incubator used in bacteriological laboratories. It is large enough to hold a dozen or more trays. There is an opening at the back through which the fumes are withdrawn and a pipe which conveys them to a water tank where they are dissolved.

An aspirator is used to suck out the fumes and to prevent thtm from escaping into the room. Formerly sulphuric acid was used instead of oxalic. The reaction which takes place in the chamber is probably as follows:

6 $KClO_3$ (potassium chlorate + 3 $H_2C_2O_4$ (oxalic acid) = 3 $K_2C_2O_4$ (potassium oxalate) + 6 $HClO_3$ (chloric acid).

6 $HClO_3$ (chloric acid) = 2 $HClO_4$ (perchloric acid) + 2 Cl_2O_4 (chlorine tetroxide, or chlorine dioxide) + 2 H_2O (water).

3 Cl_2O_4 (chlorine dioxide) + 2 H_2O (water) = 4 $HClO_3$ (chloric acid) + O_2 (oxygen) + Cl_2 (chlorine).

The initial reaction results in the formation of chloric acid, which at once decomposes into chlorine dioxide, water and perchloric acid, which is stable. Under the action of sunlight the chlorine dioxide is changed to chloric acid, oxygen and chlorine, while the latter decomposes water and sets free more oxygen. The process, therefore results in the liberation of nascent oxygen which is really the active disinfecting agent. The reactions are in reality more complicated than the above and no one has studied out just what actually takes place. The perchloric acid and hydrochloric acid formed act, no doubt, on the carbonates in the water, setting free carbonic acid.

The solution of chlorine dioxide is allowed to trickle into the effluent from the Howatson filters, after which the water passes through the "sterilizing chamber." This is covered with glass and great stress is laid on the action of the sunlight. They do not run the plant during the night except during the height of the season.

The water entering the sterilizing tank has a slight yellowish color and a distinct odor of chlorine—so much so that it is distasteful to drink, but in the tank effluent this is not noticed, although the water tastes brackish. In the open pure water reservoir, which has a capacity of about one day's supply, the water gets a further bleaching and as pumped to the city it is absolutely clear and colorless. The attendant told me that they used 180 parts per million, or about 10 grains per gallon, of the combined chemicals. The plant has been in operation in its present shape for about three years and is said to have given general satisfaction. The manager said that the bacterial efficiency was excellent and promised to send me a report stating the results of tests, but this report has not yet been received.

A number of objections have been raised against this process, which seem to be well founded. It is expensive; the chemicals used are costly compared with alum, soda, etc. The chlorine dioxide gas used is explosive at high temperatures, and it is understood that accidents have already occurred. Chlorine compounds of a somewhat objectionable character remain in the water for a considerable time after treatment. The chlorides are permanently increased. The free carbonic acid is increased if the water is hard, and hydrochloric acid may remain if the water is very soft. The process is not one to be commended, but is interesting as showing the limits to which the chemical treatment of a drinking water may be carried. I could not learn that the use of the water thus treated has had any bad effect on the health of the community.

At Middelkerke (permanent population, 2,000; summer population, 12,000), another sea-shore resort, a few miles west of Ostende, the public water supply is also disinfected with a chlorine compound. This is the so-called Ferrochlore process, also devised by Dr. Duyk. It is used in conjunction with a Howatson filter. Ferrochlore is the popular name given to the product obtained by mixing solutions of ferric chloride and chloride of lime. The reaction results in the formation of hypochlorous acid and ferric oxide—the one a disinfectant, the other a coagulant. The reactions which occur may be represented by the following equations:

Fe_2Cl_6 (ferric chloride) + 3 CaO_2Cl_2 (calcium hypochlorate) + 3 H_2O = 3 $CaCl_2$ (calcium chloride) + Fe_2O_3 (ferric oxide) + 6 HClO (hypochlorous acid).

The hypochlorous acid thus formed is fairly stable in dilute solutions, but gradually changes to hydrochloric acid and oxygen, thus:

2 HClO (hypochlorous acid) = 2 HCl (hydrochloric acid) + O_2 (oxygen),

TABLE I.

RESULTS OF BACTERIOLOGICAL EXAMINATIONS.

	Number of Bacteria per Cubic Centimeter					Test for Bacillus Coli. (+ indicates presence.) (o indicates absence.)				
	Aug. 11.	Aug. 22.	Sept. 22.	Sept. 30.	Oct. 17.	Aug. 11.	Aug. 22.	Sept. 22.	Sept. 30.	Oct. 17.
Raw water	12,800	6,800	5,000	4,230	6,500	+	+	+	+	+
Filter effluent	2,320	620	40	12	10	+	o	o	o	o
Distribution reservoir	478	180	18	6	4	o	o	o	o	o
Tap in city	296	22	12	18	12	+	o	o	o	o

Actually the reaction is probably much more complicated than this, but it is hardly worth while to speculate on the various reactions which might occur with waters of different character. The main feature of the reaction is the joint production of a coagulant and a disinfectant.

At Middelkerke the process is carried on as follows: The water supply is taken partly from wells and partly from the Plasschendaele-Nieuport Canal. The latter is used as an auxiliary supply during the summer when the population is increased. The canal water is filtered through Howatson filters, but ferrochlore is used as the coagulant instead of alum. The capacity of the plant is said to be about 300,000 gal. per day, but the average summer use from the canal is not much above 100,000 gal.

The two chemicals, ferric chloride and chloride of lime, are dissolved in separate tanks and are mixed just before they are applied to the raw water at the top of the filters. The period allowed for coagulation is very short, yet the coagulation at the time I saw the plant in operation was good. The filtered water was clear and bright, tasteless and odorless. The engineer tested the water with starch-potassium-iodide solution to determine the presence of free chlorine. The water on the top of the filter turned dark blue at once, indicating free chlorine, but in the filtered water there was only a trace of the blue color, which, the engineer said, would disappear completely on standing a few hours.

The ferrochlore process was studied experimentally at Middelkerke before it was adopted for the general supply, and afterwards it was tested at Montsouris, Paris. It has been favorably considered by a number of water-works engineers on the continent, but thus far its use has not been extended. Several papers and reports have been written describing the results and giving the results of the experiments which have been made. Among these are (1) "Nouveau Procede d'assainissement des Eaux," par M. Duyk, Brussels, Oct., 1902. (2) "Note sur le Procede au Ferrochlore," par M. Duyk, Technologie Sanitaire, Vol. IX, No. 3, p. 57. (3) "Procede de Sterilisation des Eaux potables dit Ferrochlore," a report to the French Minister of the Interior by MM. Ogier and Bonjeau (printed for private distribution). (4) Reports of Dr. Miquel and M. Albert Levy on the "Sterilisation des Eaux par le ferrochlore procede Duyk et Systime Howatson." (Extracts printed for private distribution.) A few extracts from these reports may be of interest.

The experiments at Middelkerke were carried on from July to October, 1902. The capacity of the experimental plant was 40,000 gal. a day, and the purified water was used as a part of the city's supply. During the trial bacteriological examinations were made by Dr. Henseval, professor a l'ecole de Peche d'Ostende, of samples collected from the raw and filtered water and from the distribution system of the city. The results obtained are given in Table I.

On the days when these analyses were made the amounts of chemicals used were about 1 grain per gallon of ferric chloride and about 1.2 grains of chloride of lime. This was said to be equivalent to about 5 parts per million of active chlorine.

A typical chemical analysis made during the test is given in Table II.

The Montsouris experiments were carried on in 1903 under the authorization of M. George Bechman, then chief engineer of the Paris water works. During April, May and June tests were made by Dr. Miquel and Dr. Albert Levy for the city, and during November by MM. Ogier and Bonjian representing the Comite Consultatif d'Hygiene Publique de France. The capacity of this plant was about 25,000 gal. a day. There were two Howatson filters 1 metre in diameter and 3.3 metres high, with tanks above them for mixing the chemicals. The published reports give little or no information as to the size of the sand used, the rate of filtration, the amount of wash water, etc.,—facts which are necessary to a proper understanding of the operation, but the quantities of chemicals used and the analyses of the water are given with more or less detail. The experiments were made on the water from the Seine and also on the ground water from the Vanne.

TABLE II.

TYPICAL CHEMICAL ANALYSIS.

Average of Samples collected July 27, 28, 29, 1902.

	Parts per Million.	
	Raw Water.	Filtered Water.
Appearance	Yellowish, turbid	Clear, colorless
Odor	Pronounced marshy	Very slight
Total solids	832	772
Loss on ignition	232	128
Fixed solids	600	644
Permanganate absorbed	25.4	19.0
Nitrogen as aluminoid ammonia	1.200	0.500
Nitrogen as free ammonia	2.000	1.100
Chlorine	220	240
Free chlorine	0	Slight trace

Chemicals used, grains per gallon—Chloride of lime, 0.9; ferric chloride, 1.2.

Some of the results obtained during the November tests are given in Table III.

The Seine water contained about 9 parts per million of chlorine, and 4 parts of organic matter (permanganate test in acid solution). The Vanne water contained 7 parts of chlorine and less than 1 part of organic matter. Both of these waters were much purer organically than the water at Middelkerke.

On the basis of the above experiments it is seen that 4 parts per million of chloride of lime was sufficient to sterilize the Seine water, and 0.75 part, the Vanne water. It is said that the amounts of chemicals needed for ordinary water supplies varies from 0.1 to 0.8 grain per gallon of chloride of lime and from 0.8 to 5.0 grains of ferric chloride.

One advantage claimed for the use of the ferrochlore process is the rapidity with which the floc is formed, thus doing away with large coagulation basins. One decided objection is the increase in the chlorides in the water; another is the possibility of the persistence of hypochlorous acid in the treated water. Considering efficiency and cost it is difficult to see, from the data at hand, how this system has any advantage over the older methods of mechanical filtration using alum. In certain special cases, however, it may be useful.

The use of chloride of lime as a disinfecting agent was the subject of an interesting paper given by Dr. Samuel Rideal to the Royal Sanitary Institute in 1905. (On the Sterilization of Effluents, Journal Royal Sanitary Institute, Vol. XXVI, No. 7). Among other things it gave an account of some experiments conducted by him showing the efficiency of this chemical in sterilizing sewage effluents and waters of different quality. It was stated that the amount of available chlorine required to produce a satisfactory degree of sterilization varied with the character of the liquid and was about 1.7 times the oxygen consumed in the five-minute test. Effluents from primary contact beds required 20 parts per million of available chlorine, secondary effluents required 10, and tertiary effluents, 2.5, with one hour's exposure. Drinking water (character not stated) required less than 1 part per million. The general conclusion was that an ordinary sewage effluent of good quality required about 5 parts per million of available chlorine to give a practical sterilization.

As the available chlorine in chloride of lime is generally less than 25 per cent. of its weight, the above figures would have to be multiplied by 4, at least, in figuring the cost of the method.

Calcium and sodium hypochlorites have been used in many places, for sterilizing sewages and are in very general use as disinfectants. They have even been used for water. After the typhoid epidemic at Maidstone, England, the entire distribution system was disinfected with a solution of chloride of lime. The question of the relative advantages of calcium and sodium hypochlorites was discussed at some length a number of years ago in connection with studies of what was called electrozone, i. e., sodium hypochlorite prepared by the electrolysis of salt water. It was practically decided that it was the available chlorine which was the active agent and whether or not the calcium or the sodium salt was used made little difference. The latter has a slight advantage, however, in giving less sediment, thus being somewhat more convenient to use. Chloride of lime used with soda has been suggested in place of the sodium hypochlorite electrically produced.

It seems to be generally accepted that it is the oxygen liberated by the so-called available chlorine which is the real disinfecting and oxidizing agent when chlorine compounds are used. What is needed to be known, therefore, is the amount of nascent oxygen necessary to be used in oxidizing the organic matter in water and to bring about a destruction of bacterial life. This is the same question which must be solved before an intelligent idea can be had of the ozone process. About these matters we are still very ignorant. Until the subject has been more carefully studied than it has been with reference to some of its fundamentals it will be futile to discuss the practical use of any of these methods from the standpoint of cost.

The author had intended to take up the question of the use of ozone as a means of purifying water, but, after a somewhat thorough study of the literature of the subject and after visiting some of the places where ozone has been tried, both in this country and abroad, he is inclined to believe that the time has not yet come for a full discussion of the subject. Much attention has been given to this subject, many processes have been devised for its manufacture, experimental plants have been operated, and in a few cases it has been tried on a practical scale. The general result of all this has been to establish two facts. First that the use of ozone is of considerable value as a sterilizing and oxidizing agent and may have a field of usefulness as an adjunct to filtration or as applied to clean and colorless waters. Second, that up to the present time its cost has been so great that it has not been economically successful.

Of the half-dozen or so plants where ozone has been tried in Europe it is said that only one is in regular use. A second one is used at intervals, and a third is operated occasionally for the benefit of visitors. The others have been abandoned. In all these cases it is understood that the difficulty has been chiefly one of expense.

Any process of this character must necessarily pass through a period of experiment and failure, and it is not at all impossible that in time an economical ozone process may be secured. Meanwhile there is no reason why certain scientific aspects of the question should not be taken up and brought to a satisfactory conclusion. The most important, perhaps, is the one already mentioned. "How much ozone is necessary to sterilize waters of different kinds, how much to oxidize organic matter, how much to decolorize colored waters, etc." These data could be obtained independent of the process of manufacture.

TABLE III.
RESULTS OF NOVEMBER TESTS.
Bacteriological Analysis.
Seine Water.

	Number of Bacteria per C.C.			Test for Bacillus Coli in 10 C.C. (+ indicates presence.) (o indicates absence.)		
	1st Series, Nov. 10.	2d Series, Nov. 12.	3d Series, Nov. 17.	1st Series, Nov. 10.	2d Series, Nov. 13.	3d Series, Nov. 17.
Raw water	1,869	1,428	2,120	+	+	+
Filtered effluent	1	4	10	0	0	0
Reservoir	1	4	88	0	0	0
Chemicals (parts per million)—						
Chloride of lime	5	4	3			
Ferric chloride	30	20	15			

Vanne Water.

	Number of Bacteria per C.C.			Test for Bacillus Coli in 10 C.C (+ indicates presence.) (o indicates absence.)		
	4th Series, Nov. 22.	5th Series, Nov. 25.	6th Series, Nov. 28.	4th Series, Nov. 22.	5th Series, Nov. 25.	6th Series, Nov. 28.
Raw water	260	195	250	+	+	+
Filtered effluent	0	1	13	0	0	0
Reservoir	0	1	67	0	0	0
Chemicals (parts per million)—						
Chloride of lime	1	0.75	0.5			
Ferric chloride	10	10	8			

Chemical Analyses.

	Dose				Organic matter				
	Chloride of Lime	Ferric Chloride.	Test* for free Chlorine.	Chlorides.	Acid sol.	Alkaline sol.	Dissolved Oxygen.	Hardness.	Alkalinity.
1902.									
Nov. 10.									
Seine	5	30	0	9.8	4.6	4.2	9.3	210	...
Filtered			+	23.0	2.4	2.0	..	225	...
Reservoir			0	23.0	1.4	2.0	9.9	210	...
Nov. 13.									
Seine	4	20	0	8.0	3.5	2.8	8.0	230	205
Filtered			+	15.0	1.8	1.4	9.0	220	200
Reservoir			0	17.0	2.4	1.8	9.0	220	200
Nov. 17.									
Seine	3	15	0	8.9	4.6	2.8	9.2	220	...
Filtered			+	13.5	2.2	2.7	8.7	220	...
Reservoir			0	13.5	2.6	2.1	8.9	220	...
Nov. 22.									
Spring	1	10	0	7.0	0.9	0.4	9.9	220	...
Filtered			+	11.5	0.6	0.4	9.4	220	...
Reservoir			0	11.5	1.0	1.0	9.1	225	...
Nov. 25.									
Spring	0.75	10	0	7.2	0.8	0.8	8.7	230	...
Filtered			+	12.0	0.1	0.6	9.3	230	...
Reservoir			0	12.0	0.8	0.9	9.0	215	...
Nov. 28.									
Spring	0.5	8	0	6.5	1.0	1.8	8.9	215	230
Filtered			+	9.0	0.8	0.6	8.9	215	220
Reservoir			0	9.0	0.8	0.5	9.2	230	220

* Said to be delicate to 1 part in 5 millions.

It might have been interesting at this time to have considered the different methods which have been used for the manufacture of ozone, and some of the ways in which it has been applied to water purification. This seems hardly necessary, however, in view of the publication of the elaborate work by H. de la Coux on "L'Ozone et ses Applications Industrielles." It has been thought best to simply present a list of the more important articles which have appeared on the subject, and await the results of more exhaustive scientific studies before taking up the subject in extenso. [This list is too long to be here reproduced.]

The literature on the subject is extremely disappointing in many respects. Reports which state the amount of ozone used do not indicate whether a smaller amount would have been satisfactory. Generally the analyses are given for the raw water and for the water treated with ozone, even when a filter was used in connection with the sterilizing process. The published analyses do not often show the work of the ozone process alone.

Ozone is often applied in excess and the amount used is determined by making analyses of the water after treatment to determine the residual ozone. This gives inaccurate results for the reason that some of the ozone is changed to oxygen without doing any work. The tests for determining ozone are not always comparable and differences of 25 to 50 per cent. may easily be made.

From the somewhat conflicting data at hand the extreme limits of ozone which have been used are 0.3 to 3 parts per million of ozone. Most of the figures lie between 1 and 2 parts per million. The reports do not show any definite relation between the number of bacteria in the untreated water or the amount of organic matter and the quantity of ozone used, and it is very evident that the process has been applied in most cases in a haphazard manner. In a general way fairly turbid waters and those which contain a large number of bacteria require the most ozone and the data in Table IV may be taken as approximately indicating the quantities which are necessary under the average conditions of past practice.

TABLE IV.
QUANTITY OF OZONE REQUIRED.

	Parts per Million Gallons.
Ground waters	.5 to 1
Surface waters, filtered to remove suspended matter	1 to 2
Surface water, imperfectly filtered	2 to 3
Surface waters, turbid or colored without preliminary filtration	3 or more

The East River Tunnels for the New York City Terminus of the Pennsylvania, New York and Long Island Railroad.—III.

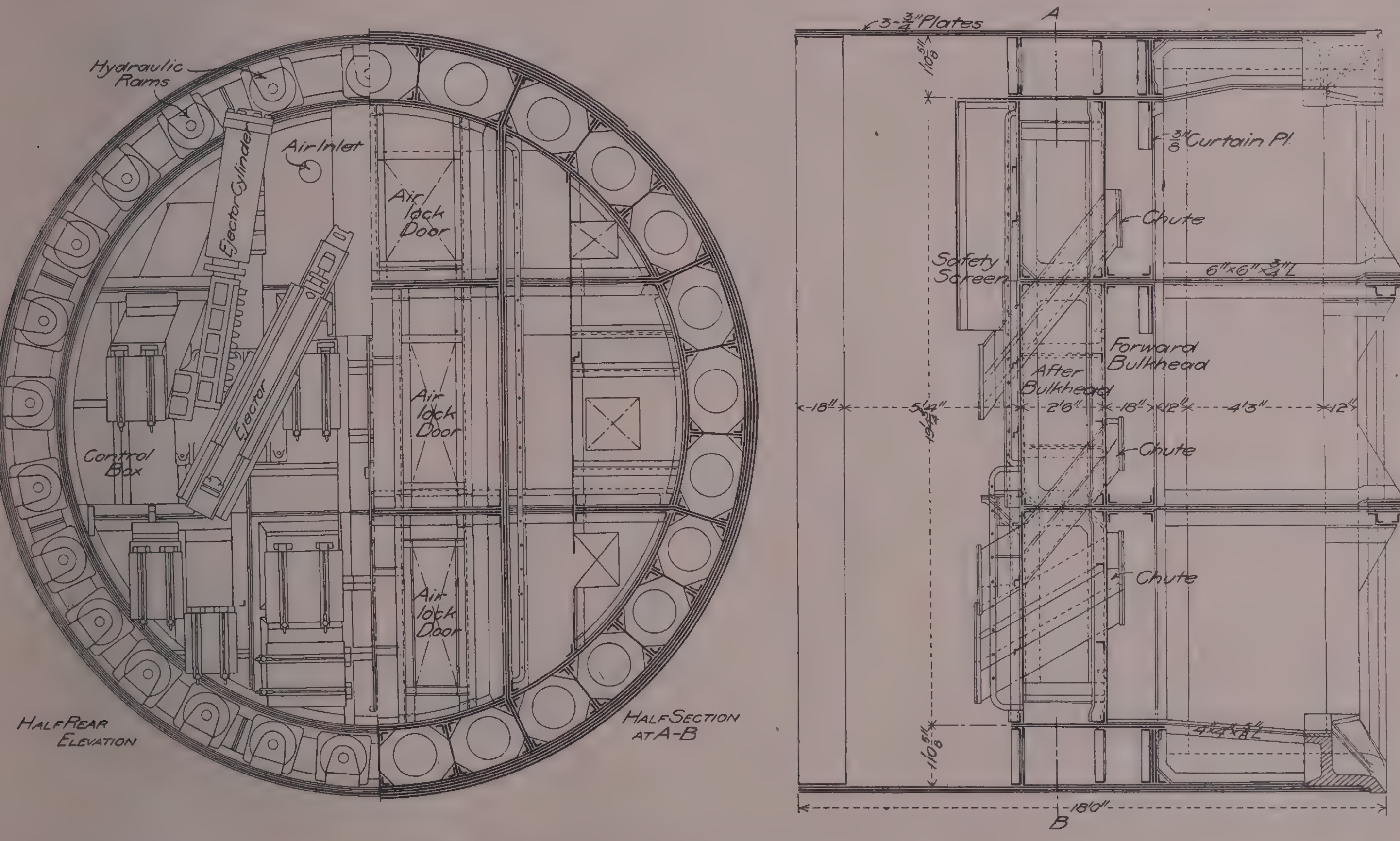
The East River tunnels of the Pennsylvania, New York and Long Island Railroad consist, as previously stated, of four approximately parallel 23-ft. cast iron tubes about 3,900 ft. long and about 90 ft. in maximum depth below high water level. The general features of their design were illustrated and described in The Engineering Record of Oct. 10 and 17, 1903, since when no description of the work has been permitted by the management until the general description which was published in The Engineering Record for July 7, last, outlining the progress and present condition of the work, and followed by the articles of July 14 and 21, describing the unusual design and construction of the great river shafts and the contractors' plant installed above the surface which includes the largest air compressor plant now in operation and exceeds in magnitude and advanced appliances most previous records for such work. The following article describes the principal methods of compressed-air work and illustrates the details of the notable shields and erectors which are among the largest ever constructed for subaqueous work and are equipped with improved operating mechanism which enables their great weights to be handled with surprising accuracy and success. The depth and velocity of the water, the character of the bottom, the great variations in the strata pierced which ranged from soft mud and quicksand to hard rock, together with the size of the tunnel make the work one of great expense and difficulty, a fact which was appreciated before the contracts were awarded and which was met by remarkably complete preliminary investigations and experiments.

The engineers in charge of the undertaking realized fully the difficulties and importance of the work and have provided for them by the adoption of the best standard methods and plant and by the introduction of new and improved features in its construction. This course has been so successful that some of the most difficult work is now well advanced and the restrictions which the management felt it necessary to impose on publication during the early stages of the work have been so far removed that the data for this series of articles has been authorized and partly furnished by the engineers and contractors and is now published with their approval. The engravings here presented are prepared from blue-prints and photographs furnished by the engineers, but a large part of the description is from the notes of a member of The Engineering Record staff who thoroughly examined the operations in the pressure headings and the various features of the compressed air plant, thus securing in this issue and in the two preceding ones completeness, accuracy and detail that would have otherwise been difficult to attain.

An important consideration in the award of the contract was the familiarity which the contractors had gained with such work by the successful construction of the great Blackwall tunnel under the Thames, in London, England, where some of the conditions were comparable with some of these here. They state that "The East River tunnel is driven at a higher continuous average air pressure than any tunnel ever before encountered; that the material now being passed through is more difficult than any previously tunneled through, inasmuch as its consistency is such that under the pressure maintained it is very fluid at the bottom of the heading and very hard at the top, thus making it extremely difficult to prevent the shield from sinking in it; that it is only by the greatest care and skill that the shell can be driven on grade, which, greatly to the credit of all concerned, is being accurately accomplished; that this shield has already passed successfully through a large variety of substances including mud, quicksand, solid rock, rock and sand, rock and boulders, and sand and boulders; that the resistance has been so great that notwithstanding the excavation in front of the shield, a total force of not less than 4,000 tons hydraulic pressure has been necessary to advance it; that when the shield encounters rock it will be necessary to increase the air pressure as much as possible to enable the rock to be drilled and blasted in front of it; that this will be accomplished by the use of shutters first used in the Blackwall tunnel and designed under the Pearson patent in consultation with Sir Benjamin Baker; that the diameter of the heading is larger than that of any other subaqueous tunnel in this vicinity, that the difficulties of construction are correspondingly greater, but would be decreased if the shield could be reduced in size; and that of all the European subaqueous tunnels, the only one which has exceeded this in diameter is the 27-ft. Blackwall tunnel which was driven direct through water bearing, gravel, and the 30-ft. Rotherite tunnel now being constructed in London."

The tunnel tubes, illustrated in The Engineering Record, of Oct. 10, 1903, consist of cast-iron shells made up with flanged rings 30 in. long, each of them divided in eleven 2,000-lb. main segments about 6½ ft. long and a key segment 30 in. long at the crown. All segments have a web of 1½ in. minimum thickness and flanges 11 in. wide over all, tapering from 2¼ to 2½ in. in thickness, those on the long sides being braced by transverse webs. The outer faces of all flanges are planed and the joints are recessed 1½ in. for calking. Each long flange is connected to the adjacent ring with six turned bolts, 1½ in. in diameter, and the short flanges are each bolted through the radial joints with five bolts. A hole in the center of the web of each segment is tapped to receive a 1¼-in. grout pipe and is normally closed by a screw plug. Deviations in alignment are made by the insertion of special beveled rings and in some cases the thickness of the segment webs is changed, as when it is increased to provide for variation in the assumed hydrostatic pressure. In all cases the segments are proportioned to resist all maximum internal and external stresses without serious deflection.

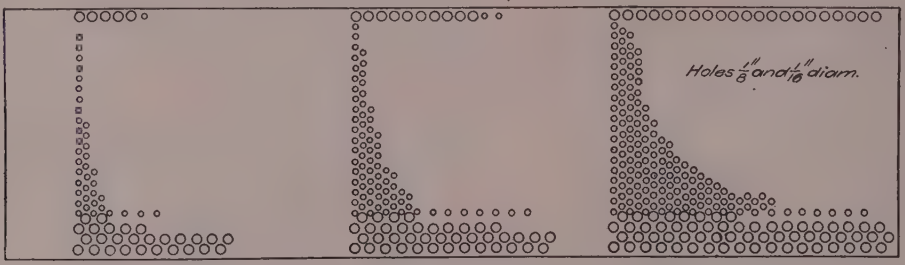
Where the tunnel is carried through rock, grout is forced outside the lining to fill all the cavities. In sand, earth or other loose material sufficient grout is used to insure a protective coating



Shield and Erectors Used in East River Headings.

over the entire surface of the cast iron. The interior of the tubes will be lined with concrete having a minimum thickness of 2 ft. above the springing line and reducing the clear radius there to 9½ ft. Below the springing line the thickness of the concrete is increased to contain the duct chambers in the vertical side walls which are 11 ft. 8 in. apart in the clear and to provide a thickness of about 2 ft. 9 in. at the middle of the invert, the top of which is 2 ft. below the top of rail.

At the foot of the Manhattan shafts the four tunnel headings were started eastwardly under the river in open excavation with wide top headings and single benches taking out the rock practically in two operations. After advancing from about 70 ft. to 80 ft. in the different tunnels the rock became seamy and so much water was encountered that it was thought wise to install the shields and pneumatic pressure for the subaqueous work. The shields were accordingly assembled in the bottom of the shafts and were moved forward into the headings. Concrete bulkheads 10 ft. thick were then built across the tunnels near the shafts, air locks were placed in them and pneumatic pressure has since been maintained between them and the headings. In the progress of the work the shields gradually emerged from rock to boulders and earth and are now in very fine sand.



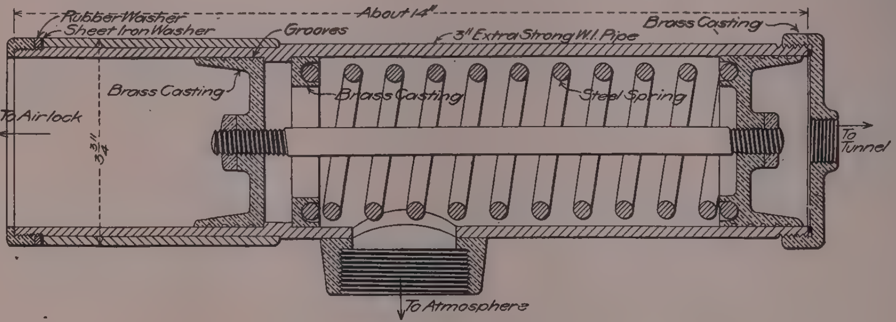
Graduated Progressive Inlets for Valve.

In order to reduce as much as possible the heavy pneumatic pressure, the grade of the tunnel was kept as high as was thought prudent and thus leaves at the thinnest point an earth roof only about 8 ft. thick between the top of the shield and the bottom of the river. This slight covering is augmented by depositing clay, dredged at Haverstraw, N. Y., until the cover is made 15 to 25 ft. in order to reduce the escape of air from the headings. Notwithstanding this deposit, the shallow distance, together with the very soft and loose character of the soil and the maximum pressure of over 35 lb. which is attained, make it very difficult to retain the air in the heading and it frequently blows out, causing some expense.

Such occurrences are, of course, anticipated in all shield tunneling in soft materials and adequate provisions for them have eliminated a large proportion of the danger, but the difficulties are greatly increased by the fact that the soil is not strong enough to hold the full pressure required at the bottom of the shield and after the pressure is reduced to that required at the top, it does not suffice to wholly exclude the water from the bottom. A mean pressure corresponding to the theoretical hydrostatic pressure near the center of the shield has therefore been adopted and it has been found possible with great care to make the excavation with it, assisted by the operation of the diaphragm and special shutters closing the front of the shield. Under this pressure the sand at the top of the shield is rapidly dried out and becomes hard and tenacious so that it has resistance and adheres when cut with tools. At the same time the identical material at the bottom of the shield flows in like thin cream and develops the treacherous qualities of unmitigated quicksand.

At the present the headings have been advanced nearly 700 ft. from the shafts in tunnels B and D, counting from the north, southwards, and are, at present, stationary in tunnels A and B chiefly in order that they may be separated by a sufficient longitudinal distance to prevent either being effected by blow-outs in the others, since they are so close together.

In Long Island City, the north shaft is completed, but the shields are not yet started, although in readiness. In the south shaft the shields have been assembled, and excavation in advance of them has been commenced under an air pressure of about 18 lb. This excavation is made with a bottom heading 9 ft. high and 13 ft. wide, which is kept about 50 ft. in advance of the full-sized excavation. The heading is drilled and blasted in the usual way, and the full-size face behind it is drilled with nine Ingersoll-Sergeant drills mounted on columns permanently attached to the front part of the shield and thus saving much time and labor in supporting them. At present the rock roof is about 15 ft. thick, and is sounded every day by two test holes about 12 ft. apart, which are inclined outwards and drilled after every blast. It is expected that the rock will extend about 700 ft. farther and that at that point the shield will encounter soft material like that on the opposite side of the river.



Automatic Pressure Reducing Valve.

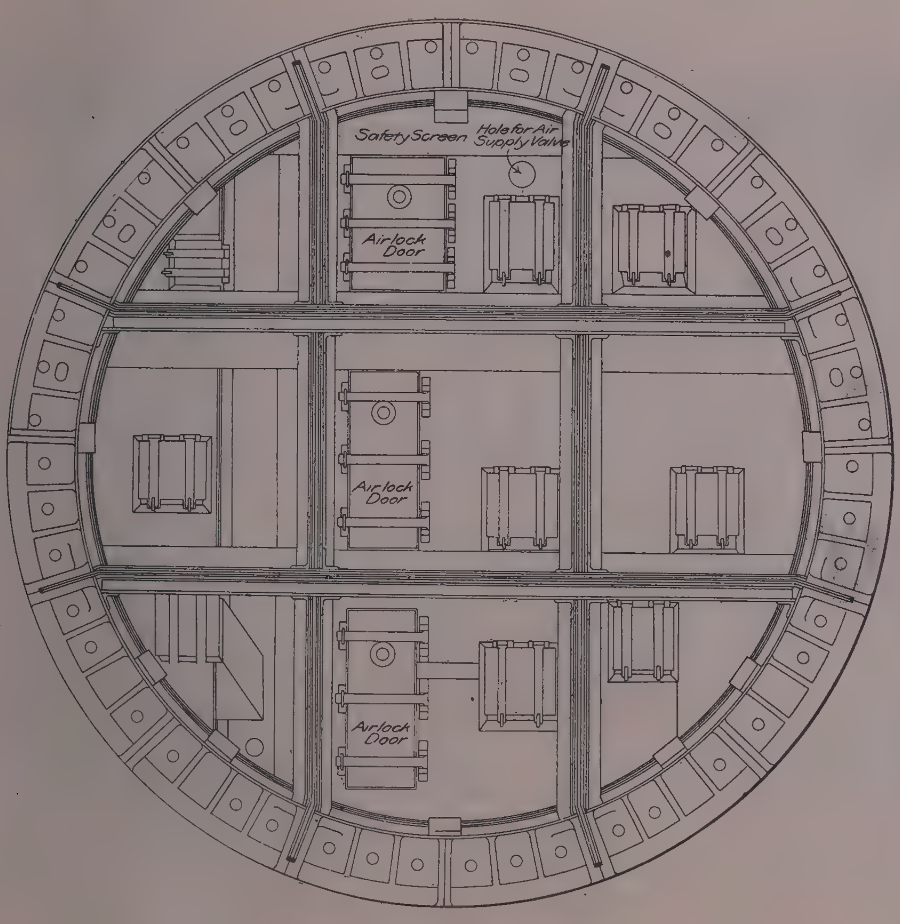
All of the river shields are duplicates and have a diameter of 23 ft. 6½ in. over all, a length of 18 ft. 6 in. and weigh about 542,000 lb. each. They are made with an outside cylindrical shell composed of three thicknesses of ¾-in. plates. At the rear they are reinforced with an additional plate ⅜ in. thick and 18 in. wide riveted to the inside plate and serving as a filler to reduce the clearance and check the leakage between the tail and the completed rings which it engages. In front the vertical edge of the shield is reinforced by a massive segmental cast-steel cutting edge 30 in. long and about 2 ft. deep. It is made in sixteen segments with radial flange joints which are not bolted together. The vertical and circumferencial webs are about 4 in. thick and the segments are connected by intermediate stiffening webs in radial planes. The inner surface of the cutting edge is enclosed by a 1x9-in. welded steel ring. Above the center of the shield the cutting edge segments have 4 in. horizontal holes parallel to the axis of the shield which are intended to receive the connections of a movable semi-circular hood, not here shown, about 6 ft. in length which can form an extension of the shield so as to afford protection from soft upper stratum when it is necessary to excavate rock below it.

Near the center of the shield are two vertical transverse bulkheads, 2½ ft. apart, made with heavy angle-iron frames and ½-in. steel plates. These bulkheads and the girders and braces in the forward part of the shield, support two horizontal working platforms about 8 ft. and 15 ft. above the lower edge of the shield which reach from the after bulkhead to the cutting edge and are provided with adjustable extensions in front to correspond with the overhang of the hood. Two vertical longitudinal bulkheads intersect the transverse bulkheads and the floor platforms and with them divide the cross section of the shield into nine separate portions or chambers. In front of the forward bulkhead these chambers can be closed with vertical transverse adjustable shutters that are movable back and forth for a distance of over 30 in., exceeding the stroke of the shield. They are moved forward by powerful screws that enable them to be pushed up against the face of the earth in front of the shield or to be withdrawn from it so as to clear it when the shield is advanced. These screws are provided with special devices to enable them to engage the shutters when necessary or to allow the latter to slip back with moderate resistance when the shield advances.

The miners work in front of the forward bulkhead with or without the protection of the shutters, two of them being stationed in each of the three large chambers and one in each of the six small chambers. When the shutters are in service small apertures in them can be opened or closed by sliding doors, leaving holes of only a few inches area through which, under the worst conditions, the miners thrust bars and dislodge the soft mud and sand so that it and the water flows in in quantities regulated by the shields and excluded when necessary. The spoil is shoveled up and deposited in inclined chutes passing through both diaphragms and delivering to the rear of the shield where it is shoveled into dump cars and drawn by cable traction to the air locks.

When the ground is not bad enough to require the shutters they are removed and the miners attack the whole face of the heading corresponding with each compartment of the shield. At present the communication is free through the transverse bulkheads between the front and rear part of the shield, but in extreme cases it is possible to close the bulkhead doors and maintain increased air pressure in front of the shield. In this case the spaces between the bulkheads serve as air locks. The chutes are also provided with doors at both ends so that they can be used as air locks for material in case the pressure varies in front and rear. A safety screen is provided behind the after bulkhead in the upper part of the shield to provide emergency retreats for the miners in case of sudden flooding of the shield.

The center part of the shield is reinforced by a fourth ¾-in. shell plate inside, and has a concentric inside cylinder about 19½ ft. in diameter and 4 ft. long. This cylinder is connected to the outer shell by 27 radial webs and the corresponding pockets between them each receive a hydraulic ram 9 in. in diameter, which reacts in front against an annular girder reinforced with very heavy horizontal longitudinal struts or girders connecting it with the cutting edge. At the rear the rams engage the last ring of the tunnel lining and together exert against it a maximum pressure of 10,306,000 lb. when operated to their full capacity of 6,000 lb. pressure per square inch. This amount has not yet been quite reached but a pressure of 5,500 lb. has generally been found necessary to advance the shield. The rams are controlled in pairs by a double vertical row of valves on each side of the shield by means of which any ram can be separately operated to increase or diminish the motion of a given part of the circumference of the shield, thus providing a means of steering the latter.



Front of Shield; Hood Omitted.

Attached to the rear bulkhead are two erectors for handling the 2,000-lb. tunnel segments delivered on cars in the completed tunnel. Each erector has two hydraulic cylinders; the plunger of one of them is adapted to engage the segment and is revolved about the horizontal longitudinal axis by the second cylinder, the plunger of which operates a rack and pinion mechanism. This enables the erector to swing into any required position, take the segment from the car, revolve it to the proper angle and then extend it radially and hold it in position until assembled to the preceding segments. The erectors are operated by hydraulic valves adjacent to those used for manipulating the shield. Immediately behind the shield is a rolling platform attached to the shield and drawn forward as the latter advances. On it are established the grouting machines and a small derrick for handling the concrete and other materials.

The outer and inner cylinders of the shields were received from the shops in eight full-length radial sections completely assembled with the boxes for the hydraulic rams, but detached from the cutting-edge steel castings. A timber cradle was built to receive it in the bottom of the shaft and on it was first set the middle lower section which weighs 19 tons and corresponds with the invert of a circular arch. The two adjacent sections were then set on each side of it and held in approximate position with clearances between them and the first section sufficient to permit the insertion in their radial joints of extensions of the webs of the two longitudinal bulkheads, the lower halves of which, together with a part of the lower working platform, were received in a single 19-ton piece. After these pieces were assembled the remainder of the 18-ton floor platform was assembled and the next two sections of the shield at the springing line were added, then the upper floor platform was erected, two more shield sections, the upper part of the longitudinal bulkheads and finally the upper segment of the shield was put in place and afterwards the transverse bulkheads, which, with their muck chutes, etc., weighed 16 tons, were assembled, completing the erection. One shield was completely assembled in 28 working hours by 15 men. All the shields were erected by 40-ton stiff-leg derricks, each with a 50-ft. boom and a 32-ft. mast seated at the surface of the ground on the cross wall of the caisson 6 ft. from one of the side walls and rigged with nine-part tackles rove with ¾-in. steel rope. The derrick legs and foot blocks had bent connection plates bolted to the caisson. The derrick unloaded materials from a railroad track on the Long Island shore and from barges on the New York shore and delivered them directly to position in the foot of the shaft. Each shield contained about 5,000 1-in. field rivets driven by Chicago, Philadelphia, Cleveland and Ingersoll-Sergeant pneumatic hammers. All of the rivet heads were countersunk in the outer skin of the shield and all of the joints were calked with pneumatic tools.

After the shields were completed in the bottoms of the shafts the lower sections of several rings of the tunnel lining were assembled on the bottom of the shaft, filling the space between the shield and the side of the shaft. The space between the outside of the caisson wall and the rock excavation was grouted and the shield was advanced by jacks reacting against the assembled rings and transmitting the pressure through them to the caisson and rock wall outside. A permanent concrete lining or cradle 6 in. thick was laid on the bottom of the rock excavation and carefully dressed to the diameter of the shields so as to support it and diminish the friction as it advanced.

The permanent cast-iron lining commences at the foot of the shaft and in the joints between the first sixteen rings there were assembled gasket-like steel plates ½ in. thick that project 6 in. beyond the outer surface of the shell, forming complete annular fins intended to act as thrust bearings against the grout which was forced into cavities in the rock, thus thoroughly locking the tube in position and transmitting the reaction of the jacks to the irregular surface of the rock.

After the shields had advanced about 50 ft. clear of the shaft, a vertical transverse concrete bulkhead 10 ft. thick was built in the tubes at the New York ends of the tunnels and in them were set two horizontal material locks 7 ft. in diameter and 20 ft. long with their centers about 6 ft. below the center of the tunnel. Each lock is long enough to accommodate two muck cars and has a 24-in. gauge track at the level of the corresponding double tracks on the timber floor of the tunnel which is about 3 ft. above the invert of the latter. Communication between the tunnel tracks and the lock tracks is made by a movable section of rails about 4 ft. long, which is displaced to allow the lock doors to be opened and closed.

In the upper part of the bulkhead wall there is a 7x24-ft. emergency lock large enough to accommodate 60 men, which is reached by ladders from the tunnel floor and communicates with an upper platform at the foot of the shaft and with a gallery or foot walk suspended from the top of the tunnel and reaching from the lock to the shield so as to afford a safe passageway above the material tracks. There is also a 2x30-ft. lock near the tunnel floor which is used for passing through timber, rails, pipe and such materials, and there is a special alignment lock, 15 in. in diameter and 20 ft. long with its center about 4 ft. above the tunnel floor, which has been designed to carry the alignment from the shaft into the tunnel without the necessity of setting up the transit in the air lock. In each end of this lock is arranged a transversely adjustable plumb bob suspended from a movable block engaging a horizontal transverse screw passing through the upper part of the tube. This block also engages a parallel smooth rod which prevents the revolution of the block and causes the latter to move back and forth with the operation of the screws. Both rods and screws are attached at the ends to brass castings accurately fitted to the exterior surface of the tube and held firmly in position against them by set screws. The adjustment rod is operated by an external thumb screw and passes through a stuffing box which was found necessary to prevent the escape of air that would otherwise cause currents sufficient to affect the plumb bob. The door at the shore end of the lock can be opened and both plumb bobs set by means of a transit aligned by the vertical wires or permanent marks at the foot of the shaft. This door can then be closed and the opposite one opened permitting a transit on the pressure side of the lock to be lined in the plumb bobs and produce the line through the tunnel without loss of air pressure or obstruction of the large lock.

This method was devised by the engineers of the railroad company and has been found very convenient and satisfactory in that it affords greater speed and accuracy in instrumental work and enables it to be carried on independently of the construction work or the operation of the large lock, and avoids the danger of displacing the instrument when the latter is set up in the large lock.

Permanent alignment marks, located about 200 ft. apart, are made in the tunnel with brass scales similar to those used in the shafts, which are secured to the roof segments, or with spads (horseshoe nails with flattened heads) driven into wooden plugs in the calking recesses between the rings. The position of each ring of the segmental lining is carefully located and recorded by the assistant engineer as soon as it is completed and a constant check is thus maintained on the grade and alignment of the tunnels which have thus far been maintained very accurately. Allowance is made for a settlement in the soft material so that the shield is continually run at a slight upward elevation and the rings are usually located about 3 in. above required grade. The method of steering the shield is very simple and efficient. The shield foreman is provided with two light wooden steering rods about 20 ft. long, each of which is graduated to hundredths of a foot at the rear end. These are held horizontally 23 ft. apart, parallel with the tunnel axis with their forward ends in contact with the after diaphragm of the shield. The relative positions of the edge of the last ring on both sides of the tunnel are then read on the graduation and either side of the shield is moved to the required position to keep it in alignment or deflect it according to the figures provided by the engineer, the operation being effected by manipulating the rams on the opposite side of the shield.

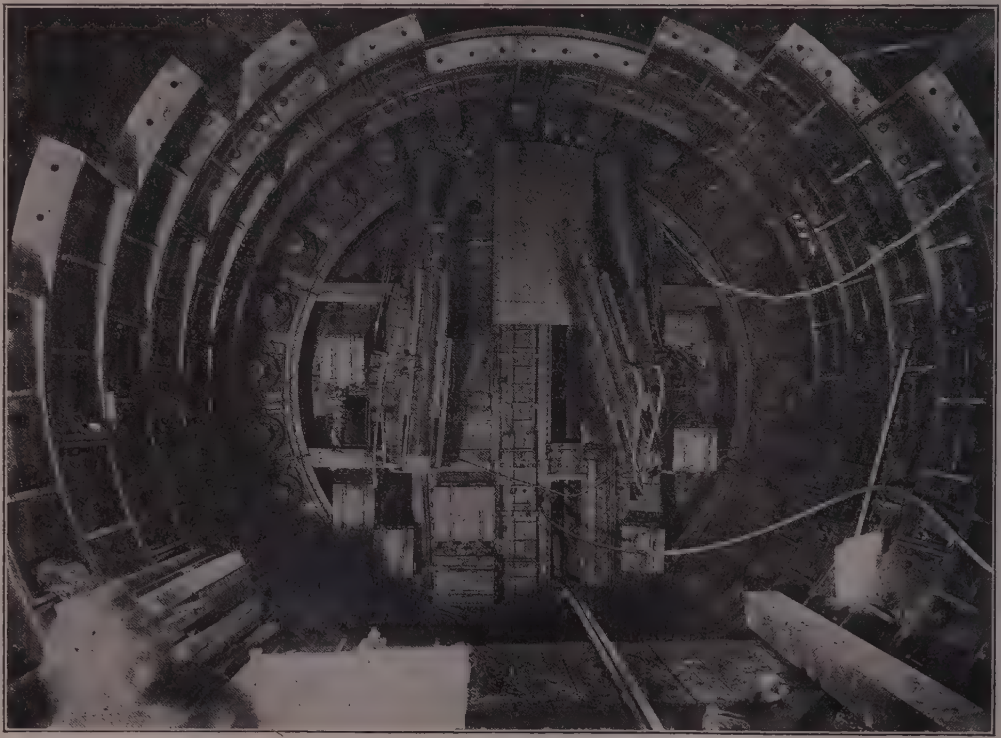
The vertical alignment of the shield is still more simply effected by means of a plumb bob suspended from the top of the shield 3 in. in the rear of the transverse diaphragm. To make the shield move horizontally it is only necessary to adjust the rams so that the foot of the plumb bob is also 3 in. from the diaphragm. To incline the shield upwards or downwards, the jacks are operated to increase or diminish the distance between the plumb bob and the diaphragm by the calculated amount. It is interesting to note that the levels for the tunnel were carried across the East River through the gas tunnel at 72d St., which was the first tunnel built under the East River.

Near the heading are maintained two safety diaphragms about 200 ft. apart which are advanced from time to time as the shield progresses. Each diaphragm consists of a vertical transverse steel plate ⅜ in. thick, stiffened with vertical and horizontal girders. The plate is semi-circular and is bolted permanently into the joint between the upper parts of adjacent rings of the lining. It thus forms a trap above the lower horizontal edge of which water cannot rise at the shore end of the tunnel until after the air in the tunnel has escaped, a process which would be very long considering the tight joints which are maintained in the lining. When the diaphragm is removed its web plate is cut out at the flanges of the tunnel ring leaving a portion in the joint where it acts as a permanent filler.

About 50 men are required to operate each shield and under present conditions they work two 3-hr. shifts daily, thus requiring 200 men to operate one shield 24 hr. The cross sectional area of the shield is about 436 sq. ft., corresponding to a net excavation of about 40 cu. yd. of material for an advance of 30 in. necessary to set one tunnel ring. The pressure required to advance the shield amounts to about 23,600 lb. per square foot of sectional area.

As before mentioned the shields are now located in very soft material in the headings driven from the New York shafts. In shafts C and D, at Long Island City, the shields are being advanced through rock excavation made in front of them under an air pressure of about 18 lb. confined by the floor and air locks in the shafts. The shields are now just being put into service in the solid rock tunnels. The air locks have been placed in the ends of the tunnel close to the foot of the shaft and are suspended in slings above the working floor until such time as the concrete bulkhead is built up around them. The tunnel excavation has not yet been commenced for tubes A and B in the Long Island City shaft.

In order to limit the rapidity of exhausting the air locks and put it beyond the power of the workmen to come through too rapidly, a special automatic valve has been designed by Mr. Japp which can be set in three different positions so as to allow the pressure to be reduced to atmospheric in either 10, 15 or 20 min. This valve, as shown in the diagram, has a cylindrical chamber opening into the tunnel at one end, and at the other opening to the air lock. An outlet in the side communicates with the atmospheric pressures. Piston heads in each end of the valve are connected together by a center rod and the one at the tunnel end engages a spiral spring seated on a fixed bearing near the opposite end of the valve. When all of the three outlets are open the pistons remain balanced, if the pressure in the air lock is equal to that in the tunnel. If the pressure in the tunnel is greater than that in the air lock, it tends to compress the spring and causes a corresponding displacement of both piston heads. As it moves, the head at the air lock end of the valve uncovers a series of small perforations in the outer brass sleeve which encloses this end of the valve. These holes establish direct communication between the air lock and the interior of the valve through which the air escapes into the outer atmosphere.



Shield and Erectors from the Rear.

The holes are arranged as shown in the diagram so that they are successively uncovered and provide an increased area proportioned to the diminishing pressure of the air so that it is allowed to escape uniformly between the lock and the outer atmosphere. Three different sets of holes are provided which correspond with the different periods fixed for exhausting the air lock. The pressure being approximately constant in the tunnel the spring and valve are maintained in the final position until the pressure is restored in the air lock and the valve operates in a reversed manner during the compression in the lock, but as it is not necessary to limit the rapidity of entrance to the tunnel, this valve is not used for that purpose and the pressure is admitted through ordinary pressure and exhaust valves.

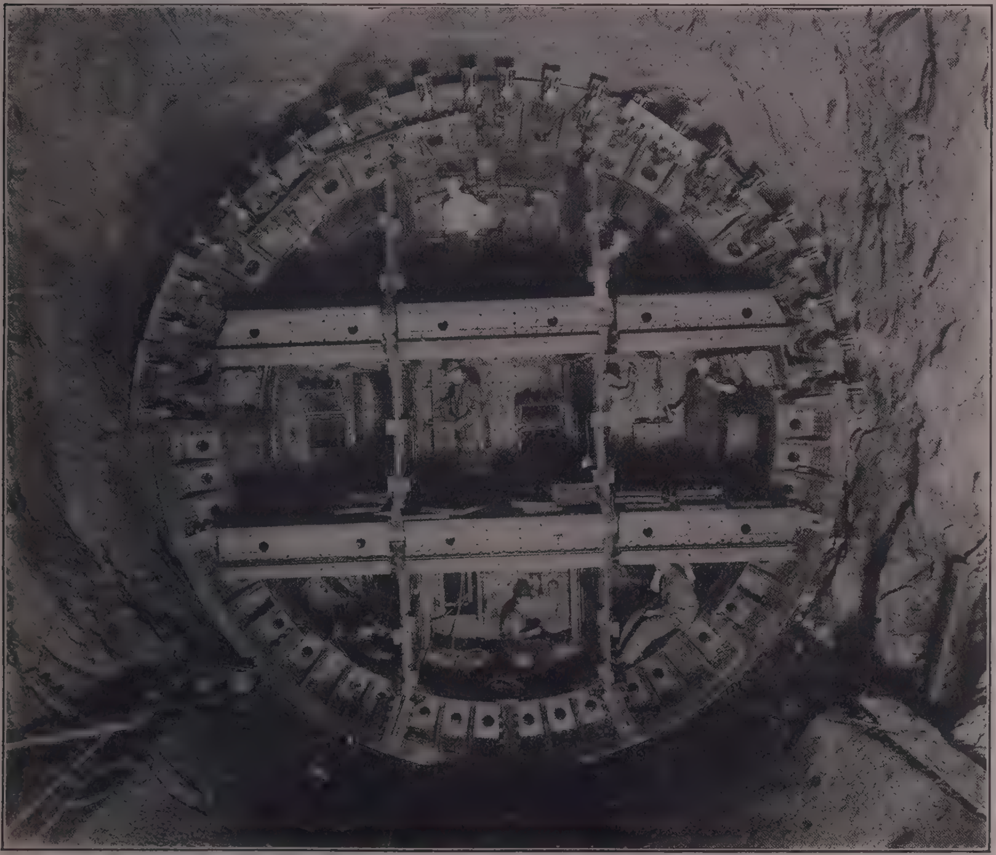
There are in all about 500 men now employed on this work under pneumatic pressure and great pains are taken to secure them against any unnecessary injury or danger resulting from it. Each applicant for work under pressure receives a thorough physical examination by the medical corps who record his age, nationality, height and weight and the report of his muscular development, heart action, pulse, respiration and whether he is subject to catarrh, cough, colds or has ever suffered from rheumatism, heart, kidney, liver or ear trouble, venereal disease, shortness of breath, dizziness or faintness, nose bleed or expectoration of blood. They also note if he has ever sustained any severe injury to the head, if he has worked in compressed air or has had compressed air illness. After the record is taken he is subjected to a preliminary trial of 28 lb. air pressure for a short time, and if the result of it is also satisfactory, after examination by a second doctor, he is accepted and provided with a badge entitling him to admission by the lock tender.

The men are strongly urged to abstain from alcoholic liquors, to observe moderate and regular diet and regular sanitary precautions and especially to follow the instructions regarding the length of time required for emerging from the air locks. If these precautions were faithfully observed it is believed there would be very little ill effect from the maximum air pressure of 35 lb. per square inch. It is, of course, impossible to enforce all of these regulations fully, especially those concerning diet, personal habits and deliberation in passing through the air locks, the men occasionally contriving to emerge through material locks which have large valves and can be operated much more rapidly than the man locks.

When the air locks are exhausted provision is made for regulating the time and safeguarding the accidental use of rapid valves and a circulation of fresh air is provided to insure proper ventilation in the confined space of the air lock. The men are hoisted to the surface in elevators which relieve them of the labor of climbing out of the shafts and at the expiration of the shifts they are provided with hot baths and have a large steam heated room in which to rest and drink hot coffee of excellent quality which is served to them free in unlimited quantities. The rooms are kept clean and are made attractive to induce them to remain and rest for some time and each man is provided with a steam dried, ventilated, locked iron-wardrobe closet or box in which he keeps alternately his street clothes and his working clothes so that they are always safe and dry for his use when entering or leaving the work. These provisions have proven very efficient, and comparatively few cases of serious sickness have occurred, considering the large number of men employed. These, and minor troubles, are treated as described in the previous article by the corps of physicians and nurses who have well equipped hospital rooms and hospital locks. At present about 500 men are employed in the compressed air and a total force of about 2,000 men is employed in all capacities by the contractors for this division of the work.

In addition to the plant located on the surface of the ground which has been described in previous articles, there are installed for the tunnel construction a total of ten shields and 270 hydraulic rams for operating them, which were built by the New York Ship Building Co., Camden, N. J.; six medical locks, built by the Logan Iron Works; 93 air locks, built by the New York Ship Building Co., 20 erectors for handling the tunnel segment and ten traveling stages to follow the shields, built by R. D. Wood & Co., and a number of Lidgerwood hoisting engines and winding engines to operate the ropes and endless cable installed in the tunnels for moving the cars. The cast-iron segments of the tunnel rings are manufactured by Davis & Thomas, Catasaqua, Pa., by J. B. & J. M. Cornell Co., N. Y., and by the Wheeling Foundry Co., Wheeling, W. Va. The steel rings are manufactured by the Mesta Machine Co., Pittsburg, and the bolts connecting the segments of the tunnel rings are made by the Oliver Iron & Steel Co., Pittsburg, Pa., and by the Cambria Steel Co., Johnstown, Pa.

Mr. Alfred Noble is chief engineer, and Mr. C. L. Harrison, principal assistant engineer. S. Pearson & Sons, Inc., are the contractors, Mr. E. W. Moir, vice-president, and Mr. Henry Japp, managing director.



Front of Shield in Rock Excavation, East River Tunnel.

Report of the Board of Advisory Engineers of the Sewerage Commission of Baltimore.—I.

The Board of Advisory Engineers of the Baltimore Sewerage Commission, Messrs. Rudolph Hering, Samuel M. Gray and Frederic P. Stearns, recently made a complete report on the proposed sewerage system for Baltimore, which report was adopted by the Commission, subject to such changes and modifications as may seem necessary and desirable. At a later meeting of the Commission it was further determined that authority be given the chief engineer of the Commission, Mr. Calvin W. Hendrick, to establish a testing plant in accordance with a recommendation in the report.

No city in our country of the size of Baltimore has as yet been required to give its sewage treatment with the object of obtaining "the highest practicable degree of purity," as required in the legislative act under which the sewerage system for Baltimore is established. Further, at the present time, methods of disposal are being operated in some parts of Europe which promise much greater economy under some circumstances than older methods. Works based upon these methods have as yet been in operation but a comparatively short time, and none of such works have as yet been tried in our country on a large scale.

We therefore felt it incumbent upon us to draw upon all available information, both here and abroad, regarding the most recent accomplishments as well as the long established experience in sewage purification. Accordingly, with your permission, we asked the assistance of Mr. George W. Fuller, Mr. H. W. Clark and Prof. L. P. Kinnicutt, who have in recent years closely studied the newer methods. Mr. Fuller also carefully studied the large European works last winter, during which season of the year in this section of the United States the greatest difficulties in sewage disposal usually arise.

We have also been materially aided by your commission and by your chief engineer, Mr. Calvin W. Hendrick, who has promptly furnished us with all information as it was needed.

Thus equipped, we have been able to reach conclusions satisfactory to ourselves, and we present them to you with the fullest confidence that they will solve the problem of sewage disposal for Baltimore in the best and most economical manner.

Methods of Sewage Disposal.—The principal methods for disposing of sewage, generally speaking, are as follows: 1. Dilution by discharge into large bodies of water. 2. Chemical precipitation for the removal of suspended matters and bacteria and of a limited portion of dissolved organic matter. 3. Intermittent filtration through natural beds of sand. 4. Intermittent filtration through artificial sand beds. 5. Filtration of partially clarified sewage at relatively high rates through filters of coarse-grained material, called, according to the method of operation, sprinkling filters or contact filters.

Various methods of sewage purification, as understood and practiced at that time, were described and discussed at length in reports of the preceding Sewerage Commission of Baltimore in 1897 and 1899. Progress in this branch of sanitary engineering, however, has been quite rapid during the past decade, and in a number of respects it is now possible to form more definite opinions than formerly as to the relative efficiency and cost of the several methods.

The well-known method of disposal by dilution, as recommended by the earlier commission, at a point well out in the Chesapeake Bay, is no longer to be considered, owing to its elimination by the legislative act creating the present commission.

Chemical precipitation, while it is capable of effecting a substantial clarification of the sewage, does not reduce the impurities sufficiently to be called at the present time a complete method of purification. It is true, however, that it does serve local purposes sufficiently well under some conditions. Ordinarily it is now regarded as a method of preparatory treatment to be followed by some type of filtration. We have not given chemical precipitation detailed consideration, because as a preliminary treatment it is not as satisfactory for Baltimore as either plain sedimentation or the so-called "septic treatment."

Intermittent filtration through natural sand beds consists in applying comparatively small quantities of sewage intermittently to beds of porous sand. It is a method which, under favorable conditions, will dispose of sewage economically and produce the most thoroughly purified effluent of any single method now known. It also has the advantage of having been practiced in this country on a fairly large scale for eighteen years, and in Europe for over one hundred years, and of having been exhaustively studied, experimentally and otherwise, by the Massachusetts State Board of Health.

Its success, however, for Baltimore is dependent upon the existence of large areas of porous sand, so situated topographically as to permit the sewage to be distributed upon the beds at a reasonable cost.

On account of the advantages of this method, and the large amount of practical and experimental knowledge regarding it, exhaustive investigations were made to determine whether or not it was the best method for disposing of the sewage of the city.

These investigations showed that the only sandy land within a reasonable distance of the city is in Anne Arundel county. The sandy land is not continuous, as clay in many places rises to the surface of the ground. Where sandy land is found it is underlaid, as a rule, by clay at a depth of but a few feet; moreover, more or less of the clay is found to be intermingled with the sand. Under these circumstances, it was ascertained by careful cost estimates that the purification of sewage by intermittent filtration through natural sand beds would be much more expensive than by other satisfactory methods, and there was further a grave doubt as to whether it would even prove efficient, on account of the fineness of the sand and the amount of clay therein. The method was for these reasons rejected. A full statement of the investigations made for purifying the sewage in this way will be found in a subsequent section of this report.

Intermittent filtration through artificial sand beds has been practiced in several places in this country with successful results. When such beds are prepared of sand fairly free from fine particles or from which such particles have been removed by washing, and when they are thoroughly underdrained, they will take care of a larger quantity of sewage per acre than is customary and practicable upon natural sand beds. Such higher rates, however, necessitate the more frequent removal of sand from the surface of the beds, which adds to the cost of maintaining them.

As the quantity of sewage which can be filtered through such beds depends to a considerable extent upon the amount of suspended organic matter in the sewage, the cost of construction and maintenance can be reduced if there is a prior removal of some of the suspended matter by sedimentation or otherwise. It was found that the best location for treating the sewage by intermittent filtration through artificial beds is on the comparatively level land on Patapsco Neck between North Point road and Back River, and south of Eastern Ave. The method of intermittent filtration through artificial beds had been rejected for economical reasons, except as a step in the recommended project. A more detailed discussion of this method will be given subsequently.

In the second report of the preceding Sewerage Commission, 1899, much attention was given to the so-called "biological methods" of sewage purification which were being developed at that date in England. In fact quite a detailed report on the matter was prepared by a distinguished English engineer, the late Mr. James Mansergh. Substantial progress within the last six to eight years in this branch of sewage purification has been made both in this country and abroad.

The advantages of preliminary clarification of the sewage under ordinary conditions, especially for large projects, has been demonstrated in a practical manner. The so-called septic tank in this case will cause a removal by sedimentation of about two-thirds of the suspended matter in the raw sewage and a liquefaction by bacterial agencies of a large proportion of the deposited sludge.

It has been found feasible to filter the partially clarified sewage from septic tanks through broken stone, coke, slag or other firm material of comparatively coarse grain, and, even with high rates of filtration, to produce an effluent which will not putrefy, and which is suitable under many conditions to be turned directly into a stream or body of water. But the degree of such purification is not so high as with intermittent sand filters. The effluent from such coarse-grained filters can be treated still further by subsequent filtration and brought to almost any desired degree of purity.

There are two types of these coarse-grained filters, namely, contact filters and sprinkling filters. The essential difference is in the method of applying the sewage to them.

Contact filters ordinarily receive the sewage by filling them with the outlet of the filter closed. After the voids are filled the sewage is allowed to stand for several hours, after which it is slowly drained out. Bacterial agencies in this way are enabled in the presence of air to operate in a somewhat similar manner to that in intermittent sand filters, as described in detail in text-books and reports.

Sprinkling filters usually are deeper than contact filters, and their distinctive feature is the manner of application of the sewage, which is distributed over the surface by spraying, in a form more or less resembling rain. These filters, therefore, give a better opportunity for the contact of the sewage with the oxygen of the air than do contact filters. They are also less likely to become clogged, as the films deposited upon the filter material become detached from time to time and pass off with the effluent. Under ordinary circumstances they are non-putrescible.

Contact filters are able to produce a non-putrescible effluent at rates several times as great as intermittent sand filters, and sprinkling filters can produce corresponding results even with much higher rates. Contact filters, therefore, are more expensive than the latter type, except where sprinkling filters may require special pumping.

As a substantial portion of the sewage at Baltimore will require pumping, and the amount of pumping with these two types of filters would differ but little, it was so obvious that sprinkling filters would be much cheaper that we have not considered contact filters in detail.

The settled effluent from sprinkling filters, when so designed and operated as to give a high degree of purity, contains only from three to five per cent. of the bacteria in the crude sewage, and the organic matter is oxidized and so changed by bacterial action that the effluent is non-putrescible. Experiments show that the effluent from sprinkling filters, when held in a setting tank, continues to oxidize and purify, and when turned into a considerable body of water there is a still further continuance of oxidation and destruction of the bacteria originally in the sewage.

We are of the opinion that it is proper from a sanitary standpoint to discharge sewage purified to the extent above described, into Back River or some of the other tidal waters at Baltimore without further treatment, but in order to comply with your instructions to devise a plan for purifying the sewage to the highest practicable degree, we recommend a plan which provides for the further purification of the settled sprinkling-filter effluent.

Two methods of doing this were carefully considered, the filtration of the effluent through so-called mechanical filters, after the application of a coagulant, more or less after the manner of water filtration, and the intermittent filtration of the effluent through artificial beds of sand. With our present knowledge, we advise the latter method as the better one for use under local conditions.

The locations for the sprinkling filter system which received the most careful consideration are on the shore of Patapsco River, near Swan Creek, and on Patapsco Neck, near Bear Creek, and also near Back River. The last site was chosen.

Plan Recommended.—We recommend the method of sewage disposal by the city of Baltimore just described, in which the sewage is purified by passing it successively through septic tanks, sprinkling filters, settling basins, and then intermittently through artificial sand filters; the works to be located on Patapsco Neck, near Back River, and the purified effluent to be discharged into that body of water.

The details of this plan are described and discussed at length in a subsequent chapter.

Separate System of Sewers.—In accordance with what is now almost universal practice, where a special treatment of the sewage is required, we recommend that the sewers be built according to the so-called separate system. In this system, the sewage is kept apart from the storm and ground water and removed in sewers, while the storm and ground waters are removed in other channels, called drains. It is not feasible to prevent a small quantity of rain water during storms from passing into the sewers through joints in manhole covers, or to wholly prevent the leaking of some ground water. Yet both storm and ground water should be excluded as far as possible by first-class design and work, and rigid rules should be made and enforced to prevent any connection with the sewers through which such waters may be introduced. The importance of such rigid exclusion may be appreciated by considering the cost of the increased sizes of main sewers, pumping stations and particularly of the sewage disposal works for which it would be necessary to provide, and by also considering the experience in many places having a separate system where during portions of the year the volume of sewage is much more than doubled by the inflow of ground water.

Quantity of Sewage.—At present we are advised that the water consumption is about 115 gal. per capita daily, on the average, or 65,000,000 gal. daily. This quantity ranges as a monthly average from about 59,000,000 to 75,000,000 gal. daily. A portion of this water, used for generating steam, washing streets and other similar purposes, and that used in buildings not connected with the sewerage system, would not reach the disposal works. On the other hand, there would enter some ground water, especially in places where the sewers are built in wet ground; also water from manufacturing establishments having their own source of supply, and water from some other incidental sources. From our experience with this subject in other places, it is our opinion that in the earlier years of the new works, the total amount of the sewage would not exceed the amount of the water supply. In subsequent years, when the sewers are extended into the less thickly populated portions of the city, and buildings are more generally connected with the sewers, the sewage increased by ground water will be materially in excess of the water supply.

The exact amount of sewage to be provided for in the future is uncertain, as it will depend upon the policy pursued in preventing the waste of water and upon the care taken to prevent ground water and storm water from entering the sewers. The general experience in American cities, where a meter system has not been adopted, is that the consumption of water per capita has increased rapidly from year to year, and in many places sewers, from which it was intended to exclude ground water and storm water, as already stated, still receive a large amount of water from these sources, particularly in the wetter portions of the year.

In making our estimate of future capacity we have assumed that special care will be taken to prevent the entrance of ground water and of storm water into the sewers. Accordingly, we reckon that in the future the average quantity of sewage will be 150 gal. per inhabitant, and to make a sufficient allowance for the fluctuations in the sewage flow at different portions of the day and of the year, for the increase of ground water during wet periods, and for the unavoidable entrance of some storm water during storms, we have assumed that double the above quantity may have to be taken care of for short periods. Under these extreme conditions, however, sewers, pumping stations and other works may be operated to their full capacity without any further margin for contingencies.

Intercepting and outfall sewers should be planned on the above basis. For a population of 1,000,000, which may be reached by growth and annexation between the years 1925 and 1935, these should be able to convey 300,000,000 gal. per day when flowing full. Pumping engines, force mains and other works, which can be readily duplicated, have been estimated of sufficient capacity to provide for an average flow of 75,000,000 gal. per day, and an extreme flow of 150,000,000 gal. per day.

The sewers as thus designed do not differ much in size and capacity from those recommended by the consulting engineers in the 1897 report of the preceding Sewerage Commission, and they may provide for a population in excess of 1,000,000 persons if the water consumption and the amount of ground water are kept as low as it is practicable to keep them.

Quality of the Sewage.—As the sewers will be designed on the separate system, it is now possible, from data available from a variety of sources, to estimate approximately what will be the average composition of the sewage expressed in weight of different substances for each person daily. This matter has been studied at length from available information, both in this country and in Europe, and due regard has been given to the influence on the composition of the sewage of various industrial establishments at Baltimore. It is unnecessary here to detail all of this evidence, but, in brief terms, it may be said that we have based our estimates on an average composition of about 14 grams of total nitrogen per capita daily, and upon total suspended matters of about 90 grams per capital daily, of which about 60 to 70 per cent. will be of an organic nature.

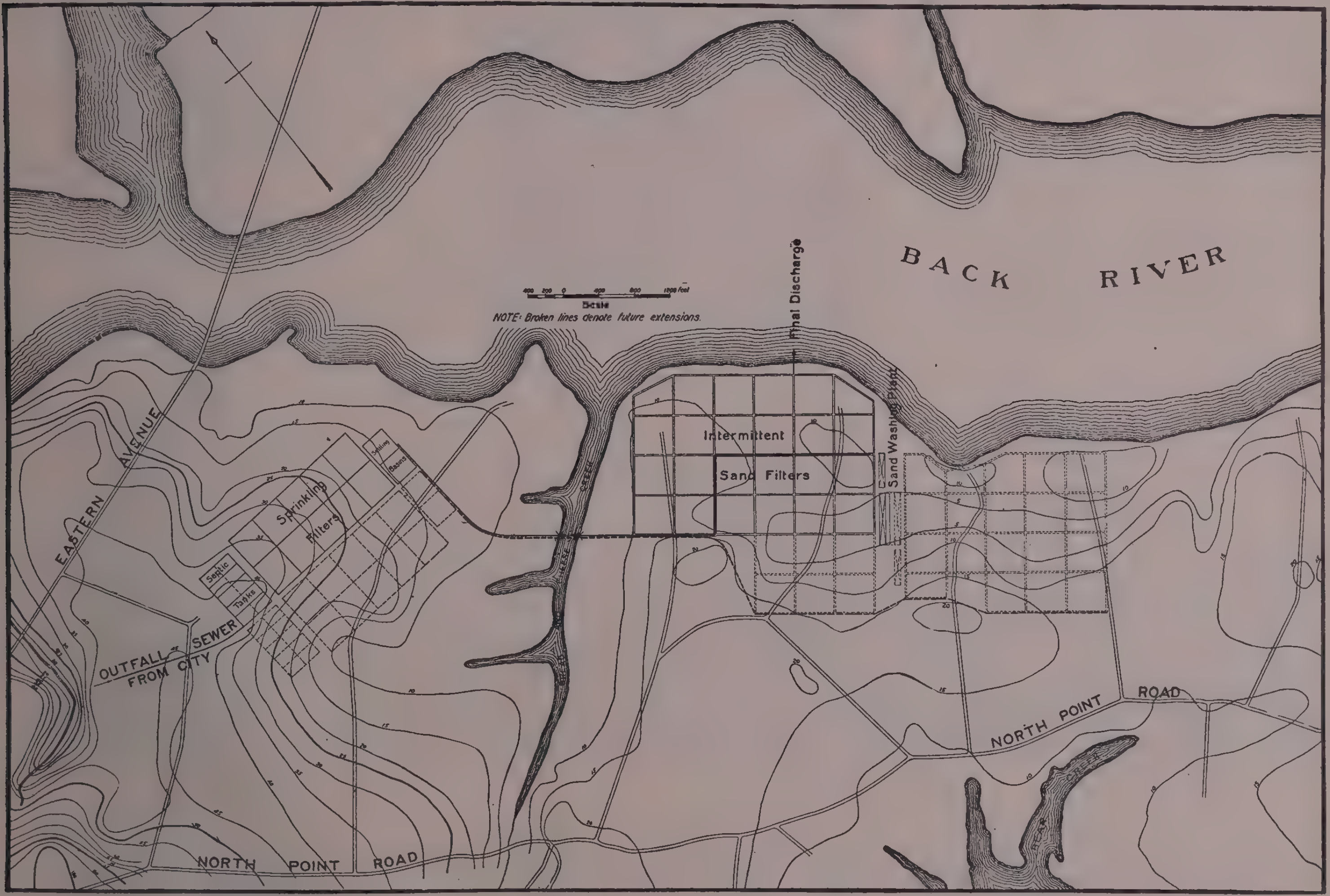
Intercepting and Outfall Sewers.—Although the problem presented to us is that of determining the best method of disposing of the sewage, the relative cost of intercepting and outfall sewers and of pumping the sewage for different locations and methods of disposal varies so much as to become a very important factor in the total cost of works. A careful study has therefore been made to determine the best plan of works for conveying the sewage to the different disposal areas considered.

Low-level intercepting sewers near the water front, for intercepting the sewage from the low territory, will be a necessity in any plan which may be adopted. If the sewage disposal works are to be located on Patapsco Neck, near Back River, the low-level intercepting sewers should run to a pumping station which may be most advantageously placed on low land east of Jones Falls. If the sewage disposal works were to be located in Anne Arundel county, the low-level intercepting sewers should run to a pumping station on the water front, near the northerly end of Long Bridge. There would be no especial difficulty in conveying the sewage to this place from as far east as the easterly boundary of the city.

It is possible, in either plan, to provide high-level intercepting sewers to convey the sewage from the higher land to the sewage disposal works by gravity, and it was found by cost estimates that it would be profitable to build such intercepting sewers in connection with the disposal of the sewage at Patapsco Neck, but it would not be profitable to build them in connection with sewage disposal in Anne Arundel county, because in the latter case the quantity of sewage which would be intercepted would be so small in proportion to the cost of the intercepting and gravity outfall sewers that it would be more economical to permit all of the sewage to run into low-level interceptors and then lift it at the pumping station.

Preliminary estimates have been made of the cost of works for conveying the sewage to several locations for sewage disposal areas on Patapsco Neck and in Anne Arundel county, but later, and before making final estimates, the number of locations was reduced to one at each place—that at Patapsco Neck, being near Back River, and that in Anne Arundel county being on the shore of Patapsco Bay, south of Swan Creek.

The cost estimates for the intercepting and outfall sewers in the Patapsco Neck plan are based upon works of sufficient size for a population of 1,000,000, except the pumping station and short force mains, which are given about one-half the ultimate capacity. The same rule has been followed as far as possible in the Anne Arundel plan. There are, however, in this plan, long crossings of tidal waters, which have been designed on the basis of one-half the full capacity. In this plan also, with the method of disposal selected, it would be necessary to repump the sewage at the disposal works to a height of 20 ft.



Preliminary Design for General Arrangement of Sewage Purification Works, Baltimore, Md.

As a result of these cost estimates, it was found that the first cost of the works for delivering the sewage would be $1,120,000 greater in the Anne Arundel plan than in the other. There would also be a much greater annual cost of maintenance in the Anne Arundel plan for operating two pumping stations instead of one, and for pumping at the main pumping station a much larger quantity of sewage to a somewhat greater height, amounting in all to $61,500 per annum. This sum, capitalized on the basis of 5 per cent. per annum, is $1,230,000, which, added to the increased first cost of the works, gives a total of $2,350,000 as the excess in cost of the Anne Arundel plan when the amount of sewage equals 75,000,000 gal. per day.

This excess in cost would become still greater in the future when the increasing quantity of sewage requires the enlargement of the pumping stations, the laying of additional pipes at the crossings of tidal waters, and increased operating expenses at the pumping station. The approximate estimate of this excess cost, when the quantity of sewage to be pumped increases to 150,000,000 gal. daily, with operating expenses capitalized as before, amounts to a total of $5,170,000.

If a plan of sewage disposal in Anne Arundel County were to be adopted which would not require a subsequent treatment of the sewage by intermittent filtration, the figures above given for the excess in cost of the Anne Arundel plan for quantities of sewage amounting to 75,000,000 and 150,000,000 gal. daily, would be decreased to $1,440,000 and $3,470,000, respectively.

We are of the opinion that the city of Baltimore would not be warranted in incurring so large an expense as is indicated by these figures for the advantage of disposing of the sewage in Anne Arundel county, on the shores of Patapsco Bay, south of Swan Creek, in view of the satisfactory disposal area which is available on Patapsco Neck near Back River. If the place of disposal in Anne Arundel county were changed to a less favorable, although nearer site, on Curtis Creek near its junction with Furnace Creek, carefully considered by us, the cost of the Anne Arundel plan would be reduced, although it would still remain materially larger than for disposing of the sewage at what we regard as a more favorable location near Back River.

Intermittent Filtration Through Sand.—In the purification of sewage by this method, the filter beds, which are level areas of sand surrounded by low banks, are alternately flooded with sewage and allowed to drain and rest, part of the spaces between the grains of sand becoming filled with air during this latter period. This alternate flooding and draining is necessary to the proper action of the filter, as the purification of the sewage is dependent on the action of certain bacteria which so change the putrescible organic substances contained in it that they are no longer capable of putrefaction. These bacteria are called "aerobic," since they can live and work only when supplied with oxygen, and this they obtain from the air which enters the pores of the sand bed during the period of draining.

The quantity of sewage which can be purified daily on an acre of filter surface depends somewhat on the coarseness of the sand, the chemical composition of the sewage, and the amount of suspended solid matter which it contains. The action of the filter is seriously affected if the sewage contains large amounts of grease and fat, or if any considerable quantities of poisonous chemicals come into it in the form of trade wastes; but there is no reason to believe that the sewage of Baltimore will be of such composition as to prevent or hinder its purification by intermittent filtration.

The filtering capacity of a very fine sand is limited by the slow rate at which the sewage passes through it, and by imperfect aeration during the draining periods, due to retention of the sewage in the pores of the sand by capillary attraction.

Filtration on Natural Beds.—As filtration on natural beds is the simplest, and, if suitable conditions exist, the cheapest method of efficient sewage purification, we carefully investigated its feasibility for Baltimore. Previous studies having indicated that the only sufficiently large area of land suitable for this purpose within a reasonable distance from the city is in Anne Arundel County, we have thoroughly investigated the possibility of intermittent filtration on natural beds in this locality.

A large number of borings were made, under the direction of your chief engineer, Mr. Hendrick, and samples of the material obtained from these borings have been carefully studied. Mechanical analyses have been made of many of the samples to determine the effective size of the sand, and we have ascertained the amounts of clay and other fine substances contained in it. Series of experiments have been made under our immediate direction with samples of sand from Anne Arundel County and other sources, and others on a larger scale under the immediate direction of Mr. Hendrick, using for the purpose both the sand in its natural state and after it had been washed to remove the clay and other particles. These experiments were made in order to ascertain the proportion of air space to the total volume of dry sand, and the extent to which water will drain out of the interstices when the sand is used for filtration.

The results of these experiments, together with a careful study of the area and thickness of the sand beds in Anne Arundel County, as shown by the records of the borings, have led us to the conclusion that, although there is a sufficient area of sand in this locality for the construction of natural filter beds to purify the sewage of the present population of Baltimore and to provide for its growth for many years, the sand is so fine and the thickness of the layers of sand is so small that, even with the removal of a large part of the solid suspended matter from the sewage by preliminary sedimentation, the possible rate of filtration would be so low that the net area of filter surface required for present purposes alone would exceed 1,600 acres.

The suitable land is in such small and scattered tracts, and is in most cases so surrounded by land which is not available on account of its elevation, the roughness of its surface or the large amount of clay contained in the soil, but which must be purchased in order to secure the usable land, that it would probably be necessary for the city to purchase a total of upwards of 5,000 acres of land in order to provide for present and future needs. For these reasons filtration on natural beds has been rejected.

Filtration on Artificial Beds.—The alternate method of artificially constructed filters would permit the sewage to be purified at a much higher rate, thus lessening the filtering surface required. The quantity of sand required to apply this method for the filtration of the Baltimore sewage is very large, but investigations made by Mr. Hendrick show that a sufficient quantity of suitable sand is available and can be obtained at a reasonable cost.

We have carefully studied this method for the disposal of the sewage of Baltimore, and have made cost estimates for construction and maintenance of a disposal plant composed of settling tanks and artificially constructed filter beds, assuming that such a plant is located in Anne Arundel county, near Curtis Creek, and on Patapsco Neck near Back River.

There are several reasons why the former location is less satisfactory than the latter, namely, the greater irregularity of the surface, which adds to the cost of construction and maintenance of the filter beds; the greater elevation of the beds, which adds to the yearly cost of pumping the sewage to them; the necessity for pumping all instead of a part of the sewage; the greater cost of the outfall sewer on account of difficult crossings of tidal waters; and, finally, a less desirable body of water into which to discharge the affluent.

The preliminary cost estimates showed so much advantage in cost, both for construction and maintenance, for the Patapsco Neck project that final estimates for this project alone have been made.

Plant for Intermittent Filtration of 75,000,000 Gal. of Sewage Daily Through Artificial Beds on Patapsco Neck.—The outfall sewer would deliver the sewage at the disposal area into sedimentation tanks of about 20,000,000 gal. capacity and of such proportions as to make the velocity of flow through the tanks about four millimeters per second (10 in. per minute). These tanks would be constructed of concrete and arranged in several sections, so that as many may be used as required to give the desired velocity of flow. The average level of the surface of the sewage in the sedimentation tanks would be about 25 ft. above high tide.

From the sedimentation tanks the settled sewage would flow to the filter beds, the surface of the sand in the highest beds being about 20 ft. above high tide. Each of the beds would have about four acres net area of filter surface, the area and shape being modified as required to fit the beds to the natural surface of the ground in such a way as to reduce to a minimum the amount of excavation and filling required for construction. The beds would be separated by earthen banks, about 3 ft. high, above the surface of the sand, 8 to 10 ft. wide on top, and with side slopes of 1.5 horizontal to 1 vertical. The bottom of the excavation would be formed into ridges and valleys, the lateral drains, of 4 in. drain tile, being laid in the valley, and gravel or broken stone being filled in over the drains to give a level surface at the height of the tops of the ridges. On top of this gravel would be placed 3 ft. of clean, washed sand, having an effective size of 0.25 to 0.35 millimeter. The lateral drains would discharge into larger drains, and these in turn either directly or through large main drains into Back River. The most economical sizes and arrangement could be determined only after more complete surveys of the proposed site are made.

The operation of this plant would be in general as follows: The sewage would be delivered from the outfall sewer into the sedimentation tanks, and as it passed slowly through them, about two-thirds of the total suspended solids would sink to the bottom and there remain; the clear liquid would pass from the sedimentation tanks to the filtration area through a conduit of concrete, and would be applied to the beds intermittently at an average rate of 150,000 gal. per acre in 24 hr.

The exact quantity to be applied at one time should be determined by experience, and would vary from time to time, being governed by the quality of the effluent from the filter beds, as determined by chemical analysis. In general, the period of resting should be from two to three times the period of "dosing," to allow of a thorough draining and drying out of the bed, and also to allow for cleaning, as will be described later.

There would be a considerable deposit of solid matter on the bottoms of the sedimentation tanks. In order to prevent the finer sludge particles from being carried on to the sand filter beds, it is suggested that the sludge might be removed at frequent intervals into smaller tanks at lower levels, these to be run as septic tanks in which much of the solid matter of the sludge would be broken up and liquefied.

While the larger part of the suspended solid matter would be deposited in the sedimentation tanks, one-third or more of it would pass to the filter beds with the settled sewage, and would be caught and retained on the surface of the sand, gradually clogging the filter and reducing the percolation. This clogging can be temporarily relieved by raking, but the solid matter would gradually work down into the sand, and it would be necessary occasionally to remove a layer of sand. It is estimated that the depth of sand thus removed annually would be 2 to 2.5 in., and would amount to from 5 to 6 cu. yd. per 1,000,000 gal. of sewage filtered. This sand would be washed and most of it returned to the beds, a layer 3 or 4 in. thick being put on as required to keep the beds up to full thickness. A small part of the sand would be lost in washing, and this would have to be replaced with new sand. The scraping, raking and handling of material would be done with horses and machinery to as large an extent as possible, in order to reduce the cost of maintenance.

Area of Land Required.—Artificial beds built as above outlined and receiving settled sewage can be satisfactorily operated as already stated at an average rate of 150,000 gal. per acre daily; the total net area of filter surface needed for the purification of 75,000,000 gal. of sewage daily would thus be 500 acres, and the total area of land which would be required to provide for present and future needs would be about 2,000 acres.

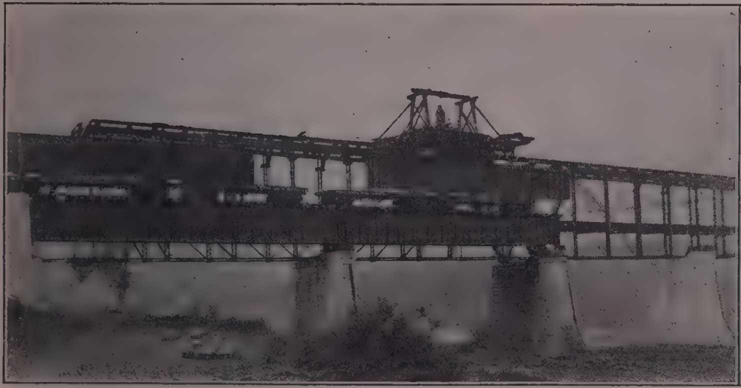
Estimates of Cost.—The estimates of cost of purifying 75,000,000 gal. daily of sewage by intermittent filtration on Patapsco Neck with artificial beds and preliminary sedimentation, are as follows:

Construction.	
Settling tanks, 20,000,000 capacity	$174,000
Conduit from settling tanks to filter beds	135,000
500 acres net area of filter beds at $6,350	3,175,000
Sludge disposal plant	40,000
Mechanical appliances, buildings, etc	199,000
Total, exclusive of land	$3,723,000

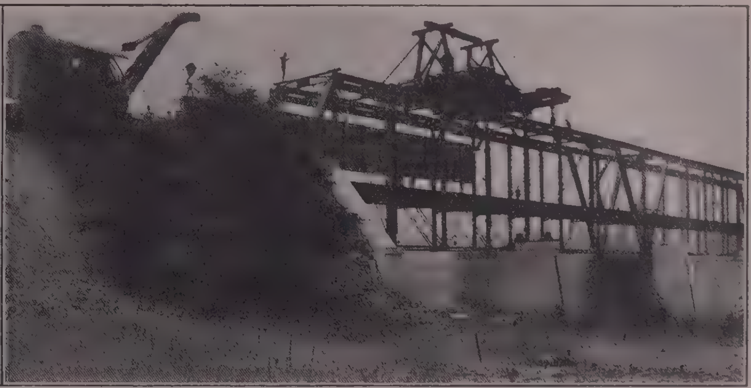
The above figures include 15 per cent. for supervision and contingencies.

Annual Operation.	
Supervision, chemical and bacteriological assistants	$12,500
Care of settling tanks	3,000
Disposal of sludge	7,000
Coal for heating and lighting, supplies, etc.	3,000
Care of 500 acres net area of filter beds at $325 per acre	162,500
Total	$188,000

A comparison of the above estimates of cost of construction and annual operation, with similar estimates of the recommended plan shows that the first cost of the former is $439,750 more than the first cost of the latter, and that the annual cost of operation is increased by $72,500. In both cases the cost of land has been excluded.



Cantilever Traveler Unloading Girders from New Track.



Cantilever Traveler and Derrick Car Moving Girder.

We have rejected intermittent filtration with preliminary sedimentation, because while the degree of purification obtainable thereby is the same as by the plan recommended, the costs for both construction and operation are materially greater.

(To be Continued.)

Plans for the James Watt Memorial Building at Greenock, Scotland, have been completed involving a two-story building of dressed stone, with a base of rough-faced granite, designed in accordance with the domestic architecture of Watt's time, have been completed. The building is to be located on the site of the cottage in which Watt was born and will have a bronze statue of Watt at the front corner. It will cost $35,000 and will be devoted to class rooms for instruction in navigation and marine engineering.

The Reconstruction of the Susquehanna River Bridge.

The tracks of the Pennsylvania division of the New York Central & Hudson River Railroad were formerly carried across the western division of the Susquehanna River at Brown's, Pa., on a single-track bridge, No. 3 of the Beach Creek district. The substructure consisted of stone masonry piers and abutments, with timber grillage footings built at a maximum depth of about 7 ft. below low water lever, or 4 ft. below the bottom of the river where the bed consists of alternate strata of sand, clay and gravel from 3 to 10 ft. in thickness.

Shoring Under Arms of Traveler.

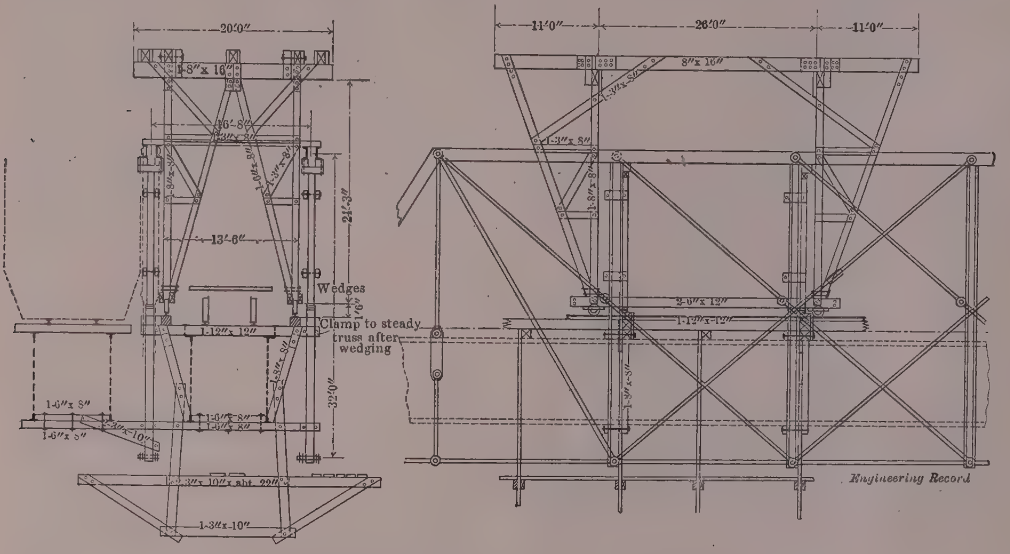
The superstructure included one 80-ft. through plate girder span over the tracks of the Pittsburg & Erie R. R. and five through spans of about 167½ ft. each. The latter had pin-connected double-intersection Pratt trusses, 32 ft. deep, supporting the floor nearly midway between the top and botom chords. They were evidently intended to reduce the amount of masonry by carrying the bridge seats as much as possible below grade at a point where there was not head room above high water level for a deck bridge. The floor beams were carried over pier centers by vertical posts rigidly attached to the main span shoes. A serious element of weakness was due to the fact that the floor lateral system was designed for comparatively light locomotive and train loads and when, after several years these as well as the number and speed of trains were materially increased, it was determined to replace the structure with one proportioned for the heavy loads and high speeds of a modern service. In order to conform with the double-tracking of the line, the bridge was also changed from single to double track. The south or east-bound track being maintained on the original center line of the old bridge, thus utilizing a portion of the old sub-structure.

As the height of the bridge above extreme low water was about 60 ft., the construction of falsework would have added largely to the cost of the new structure and a plan was devised for replacing the bridge in such a way as to avoid the use of falsework and maintain a practically uninterrupted train service. New piers were, therefore, built at the middle points of the old 167-ft. spans and the five through truss spans were replaced by ten deck plate girder spans, which practically amounted to 20 single-track, 85-ft. spans in two parallel lines. The old 80-ft. shore span was replaced by a new through deck plate girder span of the same length. The method of erecting the long and heavy girders with a derrick car and an overhead traveler with unbalanced transverse cantilever extension, was a novel and interesting one, especially designed to suit the difficult conditions encountered and was very successfully executed, thus accomplishing a task that was considered the most unique of its kind that had been undertaken on that railroad for a long time.

The cutwaters of the old piers had a very heavy batter which allowed them to be stepped off to receive a concrete extension which was corbelled out from them to support the second track and was extended on additional piles driven at the up-stream ends of the piers. This extended the original length of the pier sufficiently to accommodate the new double-track superstructure. The tops of the old piers were cut down about 6 ft. and rebuilt with 1:3:6 Atlas Portland cement concrete carried up about 3 ft. higher than the original pier top to support the new plate girders. The coping was made with 1:1:2 concrete, reinforced by a horizontal sheet of wire netting near the upper surface. It was built in successive sections, those at the down-stream end being temporarily omitted to clear the old tracks. Horizontal iron dowels were built into it and projected to bond the different sections together. The cutwater was protected with an 8x8x¾-in. angle anchor, bolted to the concrete.

The new concrete piers were about 50 ft. high from the bottom of the footing to the top of the coping and were about 29 ft. long and 5½ ft. wide under the coping and 55 ft. long and 14 ft. wide at the base of the footing. They were made with 1:3:6 concrete except the 1:1 coping and the footing was reinforced with a grillage of crossed layers of old rails just above the tops of the piles which were spaced about 3 ft. apart in both directions, extended one foot into the concrete, and were cut off about 6 ft. below low water.

The new superstructure consists of eleven double-track plate girder spans seated on the extended intermediate new piers and on the abutment at a clear height of about 53 ft. above low water and about 9 ft. above high water. The first span at the west end has two 82½-ft. through girders 9 ft. deep and 27 ft. 8 in. apart on centers, which carry a solid floor. The next nine spans each have four 84-ft., 8½-in. girders, 9 ft. deep, spaced 2 ft. and 10 ft. from the axis of the bridge. The eleventh or east end span is 83 ft. 5 in. long, making with the others a superstructure 931 ft. long between back walls. The bridge is on a 1.05 per cent. grade tangent to a vertical curve and the horizontal alignment is tangent. The bearings at alternate piers are both expansion or both fixed and the pairs of deck girders for each track are braced with lateral zig-zag angles in ten panels, alternate panel points being connected by transverse struts across the full width of the bridge. The original plan for the erection of the superstructure provided for a wooden traveler with a transverse cantilever overhang running on the top chords of the old trusses. Falsework was to be built on the north side of the old structure between the east abutment and the first pier, pony bents carrying the track on which the girders were to be delivered singly on platform cars. The first girder of each span was to be unloaded by the traveler and deposited on the falsework between the pony bents and the old trusses, the second girder was to be unloaded by the traveler and held suspended from it while the track and pony bents were being removed. It was then to be lowered to bearing on the pier and abutment and both girders were to be moved transversely to a temporary position where the cross frames and laterals were to be assembled on them and track laid. The girders for the second span were to be delivered on this track and unloaded by the traveler which was to advance one span with them and lower them to position on the piers where they would be moved transversely to a temporary position in the line of the first pair and the bracing would be assembled and the track laid and the operation repeated on the successive spans. When the new line of track had thus been completed it was to be shifted transversely until its center line was 6½ ft. clear of the old truss and traffic was to be diverted to it from the old span. This plan was somewhat modified when the work was executed and the erection was finally carried on as follows, commencing at the east end.

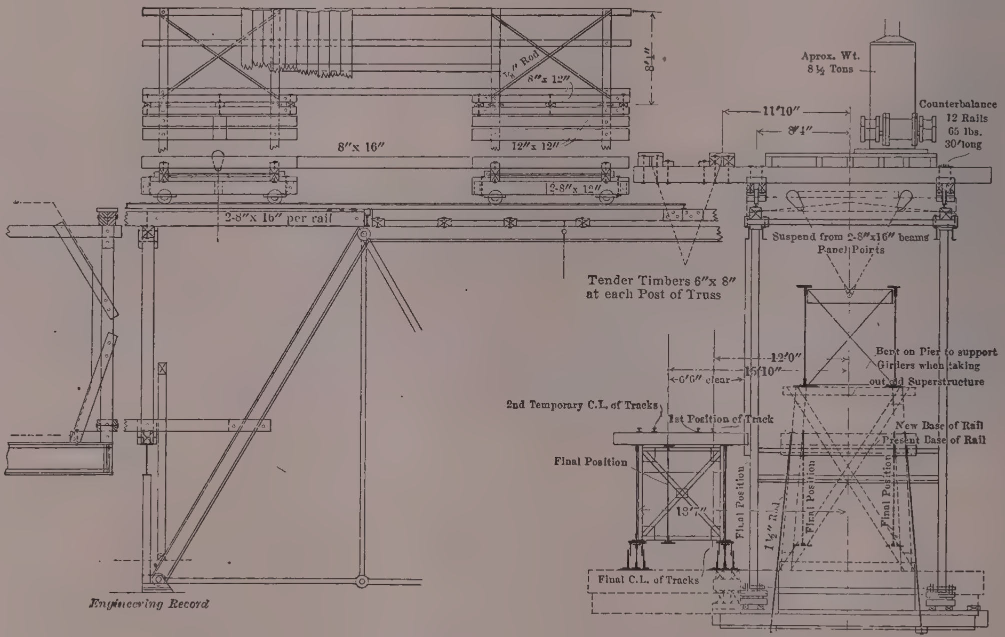


Traveler and Suspended Platform for Removing Old Spans.

Longitudinal wooden track stringers were blocked up a few inches on the top chords of the old trusses and were thoroughly spliced with fish plates to make continuous stringers for the rails of the 16-ft. 8-in. gauge traveler track. The four-wheel traveler had a timber platform about 44 ft. long with six transverse cantilever beams projecting about 11 ft. beyond the center of the north truss of the old span. They were 15 ft. apart on centers and carried on the overhang a pair of 12x12-in. jigger beams from which pairs of tackles were suspended to handle the girders. The opposite ends of the beams being anchored to the south trusses of the old spans.

The new second track having been laid up to the east abutment, the first girder was delivered on it, loaded on platform cars with the end projecting about 25 ft. beyond the end of the car. This end was lifted by the tackles suspended from the traveler cantilever and the shore end was lifted by a wreckng crane on the operating track. The cars were then removed from under the girder and the latter was temporarily lowered to the ground. The wrecking crane was then brought up to the shore end of it on the new track and with the traveler again lifted it and carried it slowly forward and lowered it to position on the outer ends of the pier and abutment. The inside girder was unloaded and erected in the same manner, the transverse and lateral bracing assembled to them, and a track laid on them on which the girders for the second span were delivered.

The inside girder was unloaded from the cars by tackles suspended from one of the jigger beams which was located in the plane of its temporary alignment of this line of girder. The traveler was then moved forward and the girder was lowered directly to its temporary position on the piers and braced to the old span by short timber struts. The traveler then returned for the outer girder, picked it up and carried it forward as described, holding it suspended vertically over the inside girder. Vertical shores attached to the cantilever beams were then lowered to position and took bearing on the inner girder already erected. They were wedged to transfer the cantilever fulcrum from the adjacent old truss to the new girder. A pair of tackles suspended from the north jigger beam in the vertical plane of the temporary position of the outside girders were then attached to the suspended girder and both sets of tackles were operated to fleet the girder outwards to its required position where it was landed on the piers. The traveler meanwhile being anchored to the opposite trusses of the old span to provide for the reaction of the cantilever arm. This process was repeated until all of the girders for the new track had been erected. The track was then shifted on them transversely until its center line was 6½ ft. clear of the old truss and traffic was diverted to it from the old span. By this modification of the method at first proposed the cantilever stresses in the traveler and the reactions in the old trusses were materially reduced and the erection was performed without risk.



Eccentric Cantilever Traveler for Erecting Girder Spans.

After traffic was abandoned on the old span the girders for the first two spans at the east end of the bridge were riveted up complete on land with cross bracing and laterals, were painted, loaded on cars, brought in on the old track, and unloaded by tackles suspended from transverse beams across the top chords of the old trusses. These sustained them while the cars were removed and light temporary safety bents were erected under them on the tops of the piers. The old floor system was then removed and the girders lowered to their final position on the piers and the permanent track was laid on them. The same operations were successively completed for the rest of the old spans. The structure then consisted of one set of new girders in temporary positions for the second track, the remaining set of new girders in final position for the old track and the old trusses and lateral systems from which the original floor system had been removed.

After the new girders were thus erected vertical posts were seated in the planes of the old truss on the extremities of 12x12-in. ties at panel points and were clamped to the vertical posts of the old truss. The upper ends were provided with cross pieces and seats to receive the top chords of the trusses and the lower ends were provided with pairs of wedges by which they were adjusted to take the weight of the old trusses. Just inside these posts two lines of longitudinal 12x12-in. stringers were laid carrying the rails for a 13½-ft. gauge track for a very light inside traveler by which the old trusses were dismantled.

The ends of the transverse timbers which supported the trusses and traveler track were knee-braced to the lower flanges of the new girders and the horizontal stress at this point was resisted by a special transverse strut fitted between the girders. As it was necessary to remove the middle panel of lateral bracing in the old floor system so as to enable the new girders to be erected special transverse braces were provided between the pairs of plate girders opposite the two center panel points of the old truss as indicated in the general cross-section and transverse elevation of the traveler and old and new spans. A working platform was suspended from the plate girder span at a convenient height for the disconnection of the lower chord panel points and the old spans were removed without difficulty while traffic was maintained on the new spans alongside. Afterwards the girders for the new track were slid transversely into the final position, jacked up, shoes taken off and placed in their permanent location. A short grillage consisting of four 12-in. I-beams was placed under each girder and the girder slid over on the shoe. This was done by pulling jacks, and about four girders with their decks were moved over in a working day of ten hours.

Cantilever Traveler Rigged With Small Fixed Boom.

Traveler in Position to Unload Girder.

The work was designed and executed under the direction of the engineering department of the New York Central & Hudson River R. R.; Mr. W. J. Wilgus, vice-president; Mr. H. Fernstrom, chief engineer; Mr. Olaf Hoff, engineer of structures, and Mr. A. W. Carpenter, engineer of bridges for main line and branches. The new superstructure weighs about 2,586,000 lb. and was manufactured and erected by the American Bridge Co. The substructure contains about 4,730 cu. yd. of new concrete and was built by the railroad company's forces under the direction of the resident engineer, Mr. R. P. Johnston. The substructure work was built in about 200 days and the new superstructure was erected and the old spans removed in about 140 working days. The erection was done by the Railroad Co. force under the direction of Mr. D. L. Sommerville, division engineer; Mr. P. L. Barker, supervisor of bridges; Mr. A. T. Hardin, superintendent, and Mr. C. W. Hunter, foreman in charge.

A Large Multi-Cylinder Gas Engine.

A sixteen-cylinder gasoline engine has recently been constructed, according to the Gas Engine, with cylinders placed at an angle of 90 deg. with each other and 45 deg. to the vertical, the sixteen pistons and connecting rods taking effect upon eight cranks, one to each opposed pair of cylinders. An important feature of the engine is that it is reversible by the very simple operation of changing the relation of the cams with the position of the piston in the stroke, similarly to the Stephenson link motion in the steam engine. This is accomplished by an arrangement of one of the two to one camshaft pinions loose on its shaft, which it drives by means of a small clutch mechanism, the position of which can be varied through 90 deg. This mechanism consists of a pin fitting into a corresponding hole in the camshaft spur wheel, and this pin can be pulled outward by means of a knob rotating through 90 deg., when it falls into another corresponding hole. Thus the camshaft is rotated through 90 deg. with reference to the piston position. The ignition timing is not upset, as the ignition plate is driven directly off a spur wheel meshing with the two to one wheel on the camshaft.

The carburation is effected upon the plan of introducing gasoline directly into the cylinders through automatic inlet valves, each cylinder being provided with its own atomizer or carbureter. These are all fed by means of a small plunger pump capable of maintaining a pressure of about two atmospheres in the whole gasoline system. The amount of this pressure is variable at will by an eccentric fitted to the pump and in this way each carbureter receives precisely its predetermined quota of fuel, thereby producing remarkable regularity of running. The air charge is drawn in through peculiar individual bell-shaped mouths and in this method of introducing the carburated charge to the cylinders all large and long lengths of inlet pipes are dispensed with and the weight of accessory parts thereby reduced to a minimum. The certainty of action is also increased to a greater degree, as each cylinder gets its charge of fuel quite independently.

The cylinder heads are made of high-tensile strength aluminum castings securely bolted to cast iron cylinders, with brass water jackets spun into position. The exhaust valves operate in these aluminum heads on inserted steel seatings, all the exhaust valves being actuated by one camshaft. A great advantage claimed for the formation of the cylinder heads in aluminum is the extraordinary capacity of that metal for conducting heat, in which respect it is about the equivalent of silver. This permits a maximum of cooling efficiency to obtain around the valves and valve seatings, although its introduction into the construction of these motors was primarily to reduce weight. With regard to weight, this amounts to a very small fraction in excess of 2.2 pounds per horse-power for the engine of sixteen-cylinder type.

A Long Steel Aqueduct for the Water Works System of Leeds, England.

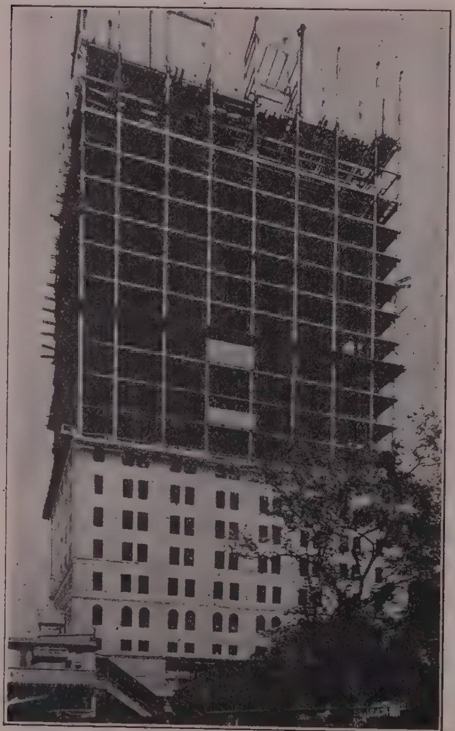
The city of Leeds, England, has decided to build a steel pipe aqueduct 11¾ miles long in connection with the water works system of that city, notwithstanding the prejudice that is said to exist among English engineers against the use of steel in preference to cast-iron on account of the fear of rapid oxidization of the steel. The pipe line will extend 11¾ miles from Kettlesing to Kirby Malzeard, and according to Mr. J. H. Armitage, chairman of the water works board of Leeds, its construction is the beginning of the second step in forming an agreement to bring the water from the works in the Ure and Colster valleys. A tunnel 5,000 ft. long is required in the aqueduct near Kettlesing to avoid carrying the line over a high elevation and the necessity of a pumping station. When the work is complete Leeds will, it is stated, have the longest steel pipe line that has so far been laid in England, a double line of pipes of over 22 miles long being part of the scheme. The development of this steel pipe industry, which is a new one for Leeds, is considered to have been a controlling factor in the decision to employ steel instead of cast-iron pipe. The contract for 11¾ miles of pipe forms only about a quarter of the ordinary work in hand in connection with the scheme. It has been stipulated by the corporation that all the pipes shall be made in Leeds, and as the Bradford Corporation—the first in England to construct a steel aqueduct—has not found a single leakage, the pipes not showing any oxidization, much is anticipated from the present experiment in the way of securing freedom from obstruction and strength of the pipe line.

The Fire Hazard of Electricity as computed from the fire losses in New York City, from 1902 to 1905, is very slight as compared with the other causes of fires. The total number of fires traceable to defective electrical wiring, or other electrical causes, was in that time only 361, which is 1.34 per cent. of the total number of fires; the total loss from these 361 fires was $207,610, which is 1.15 per cent. of the total loss from fires due to all causes.

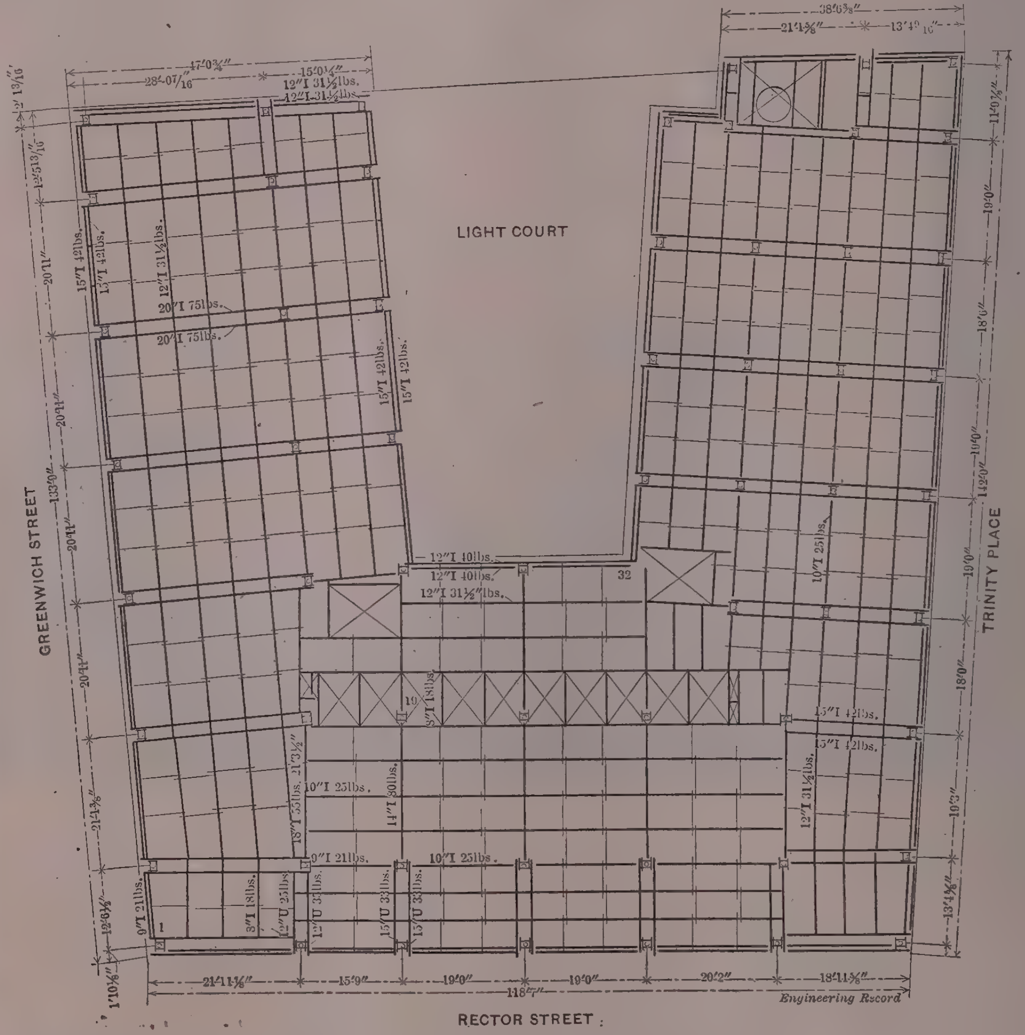
The United States Express Co.'s Building, New York City.

The twenty-two story, basement and cellar building for the United States Express Co. occupies, up to the second floor, the whole of a quadrangular lot with fronts of about 119 ft. on Rector St., and 134 ft. on Greenwich St., the opposite sides being somewhat longer. Above the first floor there is on the side opposite Rector St., an open light court about 72 ft. deep and from 32 to 43 ft. wide. The general excavation is carried down to a depth of about 20 ft. below the Greenwich St. curb, where there is a thick concrete cellar floor above which the steel framework of the building rises with 26 tiers of beams to a total height of about 325 ft. or 305 ft. above the curb.

The building is designed to be used in the lower stories for the special purposes of express business and for general commercial purposes and office rentals in the upper stories. It is of steel-cage construction with hollow-tile floors and partitions. The side and rear walls are of red brick, the court walls are of pressed brick and the front wall is of terra cotta down to the granite base course, below which all of the walls are of concrete. The main hall is finished in marble and colored terra cotta carried on a light framework of steel angles and channels. The granite was furnished by the New England Granite Co. and was quarried at Westerly, R. I. The marble was furnished by the Rutland Florence Marble Co., and was quarried at Fowler, Vt. The roof is covered with flat tiles laid in cement mortar and the cornice is of terra cotta and copper. All exterior columns are enclosed in the brickwork of the walls and interior columns are fireproofed with hollow tile. Very little wood is used in the interior finish, all floors being provided with cement wearing surfaces and the window frame being made with galvanized iron. The doors are of pressed steel and the rear windows are glazed with wire glass to a height of four stories above adjoining buildings.



Building During Construction.



Typical Beam Plan.

In many tall buildings it is assumed that the lower portion is protected from wind pressure by adjacent buildings. In this case the building is surrounded by old low buildings and no account was taken of the protection which they may afford from the wind. Wind pressure was computed at 30 lb. per square foot over the entire faces of the buildings down to street level and special provision was made to resist the stress in the framework. The girders and columns were designed for floor loads heavier than those usually assumed for office buildings and varying considerably in the different portions of the structure which are intended for the Express Co.'s quarters.

The live and dead loads per square foot respectively assumed for the floors are as follows: Dray floor, 120 and 450 lb.; working platform, 100 and 300 lb.; freight department, 100 and 200 lb.; storage floor, first floor hall, general express floor and elevated railroad corridors, 100 and 150 lb. The mezzanine floor in dray space and all floors above the first floor, 75 and 90 lb. Besides these loads special provision was made under the loading platform for hoppers carrying a daily supply of coal. An emergency supply of about 1,000 tons is carried in regular bins, under the dray space. The columns are proportioned for maximum working stresses of about 4.8 tons per square inch allowing 50 per cent. excess for wind stress. Foundation loads are reduced to a maximum of 15 tons per square foot at the bases of the concrete piers.

In the main framework there are 60 columns arranged as indicated in the typical floor plan from about 13 to 21 ft. apart at intersections of lines parallel with the street fronts. This system involved a great many irregular angles and made it extremely difficult to locate the columns accurately at the site. This was particularly true of the columns in the court walls which were located by measurements and offsets from lines diverging at very slight angles. Great care was therefore taken with this part of the work and the locations were checked several times with a transit, thus insuring such accuracy that the framework was assembled without difficulty, an achievement considered very satisfactory and creditable under the unusually difficult conditions.

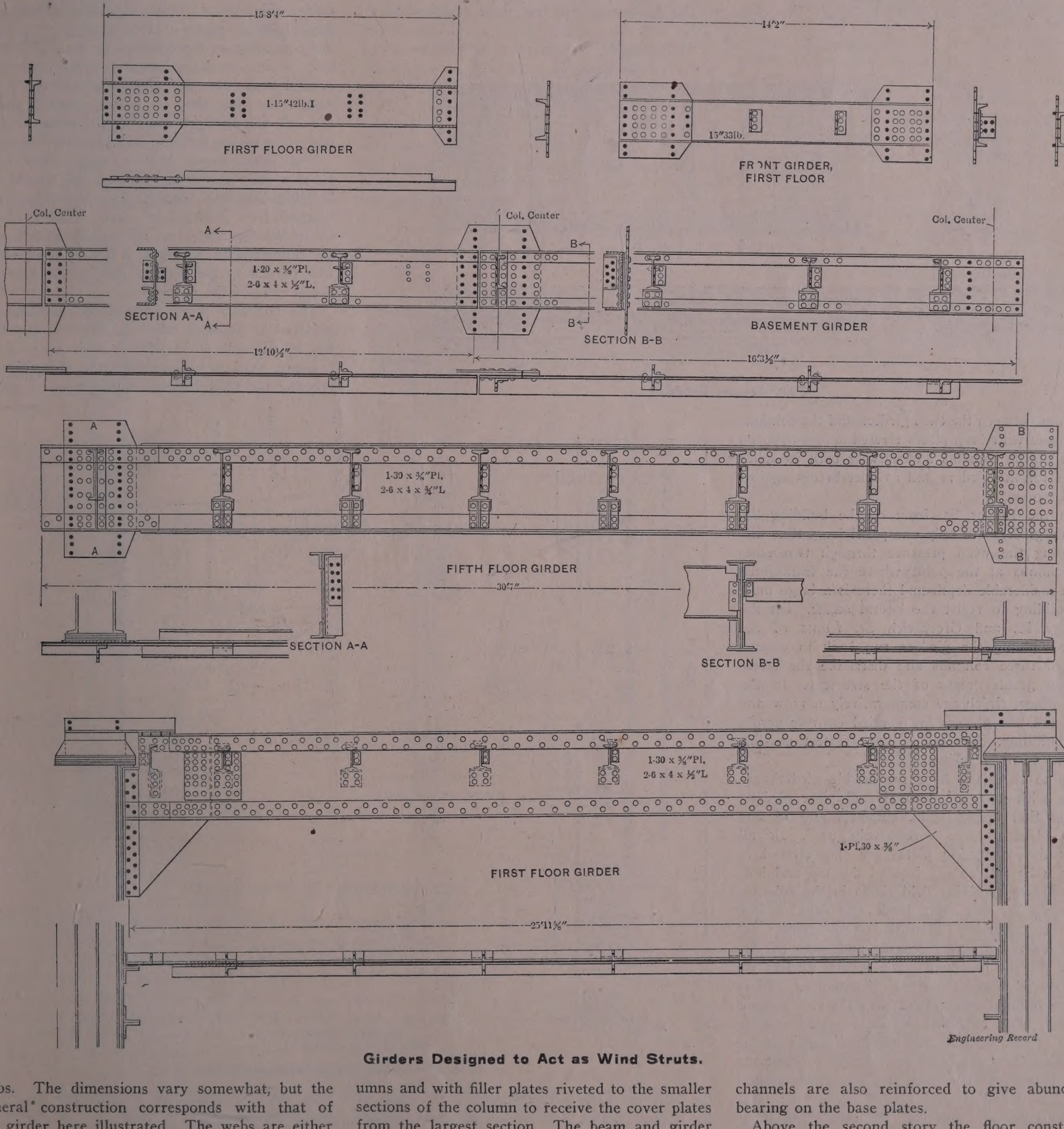
The columns are seated with pedestals or I-beam grillages on concrete piers carried down by the pneumatic process through earth, quicksand, water and hardpan to rock footings at a depth of about 40 ft. below street level, as described in The Engineering Record of March 3 last. These piers for the wall columns form a continuous water-tight enclosure for the lot and some of them receive two or more columns. The interior columns all have separate piers. Most of the grillages are made with 20 or 24-in. I-beams, but a few of them for lighter column loads are 12, 15 and 18 in. deep. The column loads are generally distributed over the grillages through transverse bolsters engaging the top flanges of all the grillage beams.

The bolster for columns 14 and 22 is one of the largest, and is typical of all. It consists virtually of three built I-beams 15 in. deep and 62 in. long, with top and bottom flange cover plates. The I-beams are each made with a pair of 15-in. channels back to back with two 15x½-in. vertical plates riveted between their webs. The edges of these plates and the flanges of the channels are planed to give a good contact with the 28x¾-in. flange cover plates. The latter are riveted to them with countersunk rivets over the bearings on the grillage beams and column base. In some cases the bolsters are modified by the omission of the reinforcement plates between the channel webs. In places where there is sufficient height the bolsters are replaced by cast-iron pedestals with radial distribution webs. Some of these pedestals are 6 ft. square and weigh as much as 5 tons each and are among the heaviest ever cast for such purposes.

At some places, especially at the corners, the column loads are eccentric with the piers and in order to load the latter symmetrically, and balance the reactions, the columns are seated on cantilever girders that distribute the loads uniformly over all the beams in the grillages. In each case these girders carry two columns, one at each extremity, and are made with triple webs. The dimensions vary somewhat, but the general construction corresponds with that of the girder here illustrated. The webs are either 4 or 5 ft. high and are reinforced at both ends with pairs of cover plates filled out so as to be flush with the vertical legs of the flange angles which they cover. Under the column bearings the fillers are made continuous serving as efficient reinforcement plates and the webs are additionally stiffened with pairs of vertical angles riveted to them and providing sufficient section to transmit the heavy shears to the grillages. The longest girders are 25 ft. 2 in. over all with columns 21 ft. 1⅝ in. apart on centers. The heaviest girders weigh about 15 tons each.

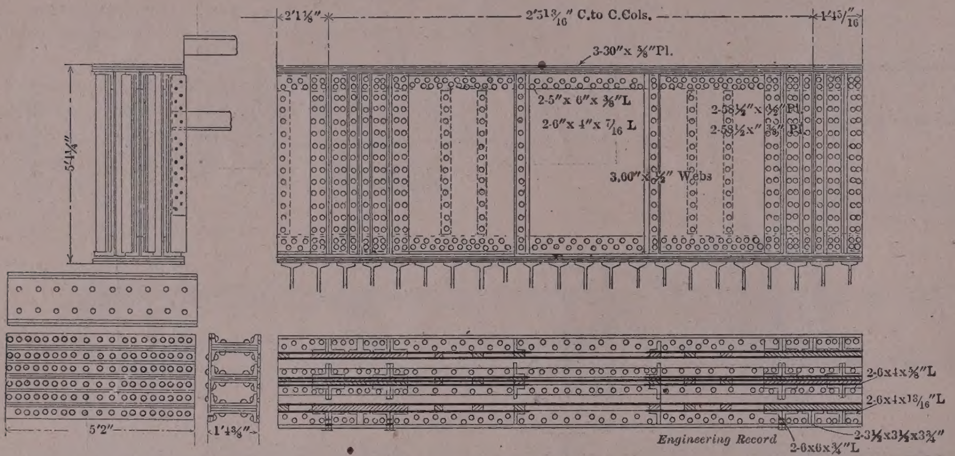
All of the columns have rectangular closed cross-sections made with two channels and cover plates and are built in sections two stories long, spliced just above the floor lines with flange cover plates. In the upper stories the columns are made with 10-in. channels and 12-in. plates. These sizes increase to 12-in. channels and 22-in. plates in the basement and where the dimensions change the splices are made with horizontal diaphragms inserted between the ends of the columns and with filler plates riveted to the smaller sections of the column to receive the cover plates from the largest section. The beam and girder connections are very simple and are made on the column webs with horizontal bracket angles engaging the top and bottom flanges of the beams and girders. The horizontal legs of the lower flange angles take bearing on the milled upper ends of vertical distributing angles in the usual manner. In most cases the horizontal angles which engage the top flanges of the beams and girders are field-riveted to the column webs. Beams and girders on the center lines of the columns are connected to their cover plates in the same manner as to the web plates. When they are offset from the centers of the columns they are supported on plate brackets extending beyond the faces of the columns in either the planes of the cover plates or parallel to the webs. The lower sections of the columns are reinforced for the increasing loads by additional cover plates. Their bases are extended somewhat and are stiffened by vertical distribution angles riveted to the cover plates and faced to accurate bearing at the lower ends. The lower ends of the channels are also reinforced to give abundant bearing on the base plates.

Above the second story the floor construction is very simple and consists of beams and girders arranged in single and double lines parallel with the street fronts, forming regular panels about 5 ft. wide. They are made with I-beams or channels from 9 to 24 in. in depth and stiffened with tie rods through their webs in the usual manner. The outer walls are carried generally by pairs of I-beams supported by cantilever extensions of the main girders beyond the column centers. The principal feature to be noted in



Girders Designed to Act as Wind Struts.

the arrangement of the beams and girders is the provision of eighteen double lines of main girders perpendicular to the street fronts. These twin girders engage the columns on opposite faces and are continuous from column to column, loading them symmetrically and providing simple connections. This type of girder is adopted to provide resistance for the wind stress, to strengthen the building laterally, and to obviate the necessity of knee-braces, diagonal rods, portals, or other systems of bracing which require special members or difficult connections, or tend to obstruct the clear spaces in the building. The connections between the twin girders and the columns are made with deep plates riveted across opposite faces of the columns and serving both as splice plates for the girders and as knee-braces against wind stresses.



Foundation Girders.

On the Rector St. front of the building the double girders are only one panel long, thus distributing the wind pressure through two rows of columns at the point where the framework has considerable depth and there is a large mass of building to resist the lateral stress. On the Trinity Pl. and Greenwich St. fronts of the main building the girders run back to engage two or three columns and distribute the stress over a greater mass of the structure. In the rear wings, which are comparatively narrow and very tall, the girders are carried entirely across the buillding, thus giving the greatest possible rigidity to the framework there.

Up to the sixth floor the double girders are made with pairs of deep riveted plate girders. Above that height 15-in. channels and 18 and 20-in. I-beams are successively used. In all cases the connection plates are shop-riveted to their webs and extend beyond the top and bottom flanges receiving field rivets in the columns sufficient for the floor loads and wind stress. The accompanying illustrations show typical details for the different lengths and sizes of girders. In the basement some special girders directly engage the triple web distributing girders in the foundations. These have the end sections of web plate extended for field-riveted connections to the vertical web stiffener angles of the distributing girders and are notched to clear the top flanges of the latter and engage horizontal connection angles field riveted across the faces of the columns. Although the connection plates were riveted to the girders in the Pencoyd shops and the columns were made in Trenton shops, the holes matched well and no difficulty was experienced in assembling them in the field.

This style of wind bracing has the advantage of avoiding all tension on the heads of rivets and transmits the stress entirely through direct rivet shear. It is therefore theoretically advantageous and proves easy and cheap in construction and erection. More rivets are required than in some other forms of bracing, but they are accessible and easily driven and the columns and girders are found to be very easily assembled in erection. It is of course necessary to cope the inner flanges of the I-beams to provide for their connections to the columns and in detailing them care was taken to concentrate the largest possible proportion of the work on the girders, keeping the columns and beams as plain as possible. This plan, together with special attention to the fabrication of the girders, produced excellent results and facilitated both the rapidity and cheapness of the work in shop and field.

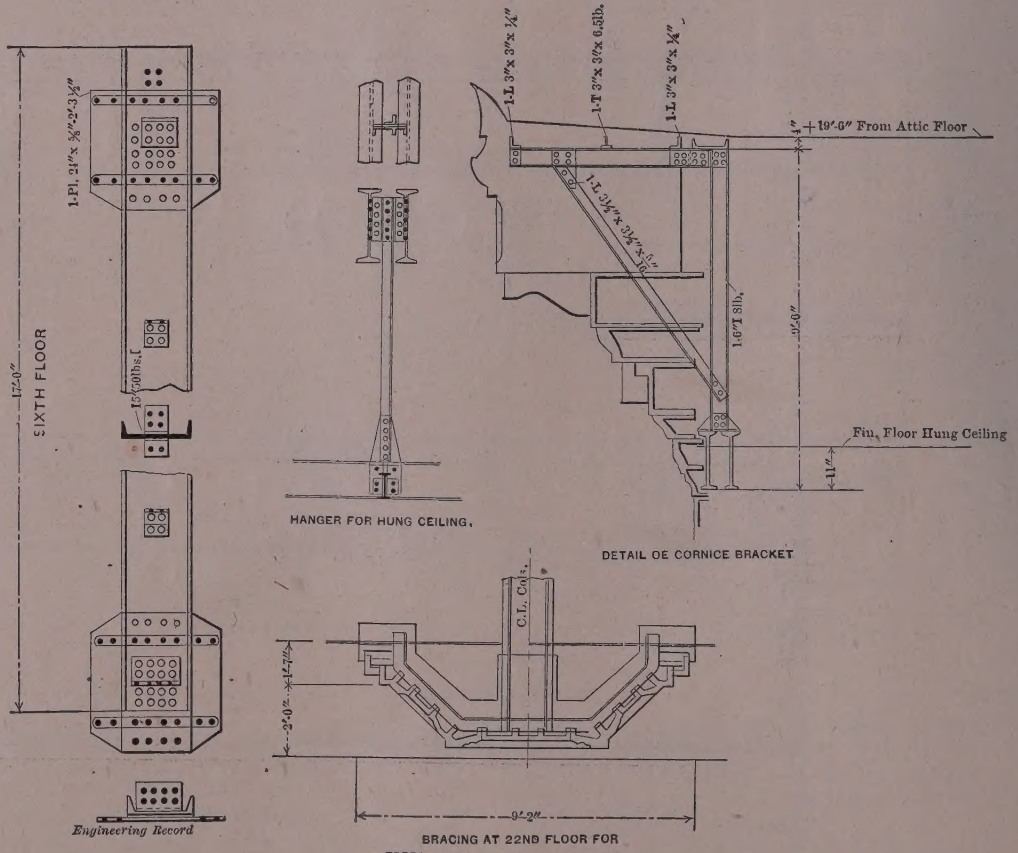
The basement and first floor beam plans of the building varied considerably from those of the typical floors, and presented great irregularities of construction on account of the many different levels necessary for the special requirements of the express building. Between the curb level and that of the general express office, different sections of the floor are built at five intermediate levels from 12 to 28 in. apart. Many of these floors were proportioned for different loadings and considerable variation was developed in the size and arrangement of the beams and girders, thus making a very complicated system of framing. The basement floor is also special in that it extends only over a portion of the building, leaving nearly one-half of the area open for the boiler settings.

At the twenty-second floor special angle iron brackets are extended around some of the wall columns to secure the ornamental terra cotta work at that level. The roof framing is substantially similar to that of the typical floors. At a variable distance below it is an extra tier of beams forming the attic ceiling and the floor of a pipe gallery, where the distribution for the different water supply and drainage systems are made. This tier of beams is called a hung ceiling, although most of the beams and girders are connected to the columns in the usual manner. A few of them, however, are directly suspended from the roof girders as shown in the detail. In this tier of beams central spaces are left for skylight wells in the center of the main part of the building and of each wing.

The street fronts have a copper and terra cotta cornice projecting about 7 ft. beyond the building line and supported by triangular steel brackets from 4 to 5½ ft. apart. They are seated on the top flanges of the outside girders and are connected at the top by a line of 12-in. channels riveted to the vertical members and to the upper ends of the columns.

The fact that three sides of the building are enclosed by elevated railroad structures and that the fourth side is in contact with an adjacent building, very much increased the difficulties of erecting the steel framework and made it necessary for all materials to be delivered by a runway from Trinity Pl. to Rector St., which passes through the court at street level and allowed the steel to be hoisted there. The runway was simply a wooden deck carried partly by the steel beams of the permanent structure.

The steel was delivered by trucks and was hoisted to the required level by four guyed derricks, one on each corner of the building, located so that all of them could hoist from the court and interlock with each other. Each derrick handled the steel in its own territory and no other, so that there was no shifting of materials



HANGER FOR HUNG CEILING.

DETAIL OE CORNICE BRACKET

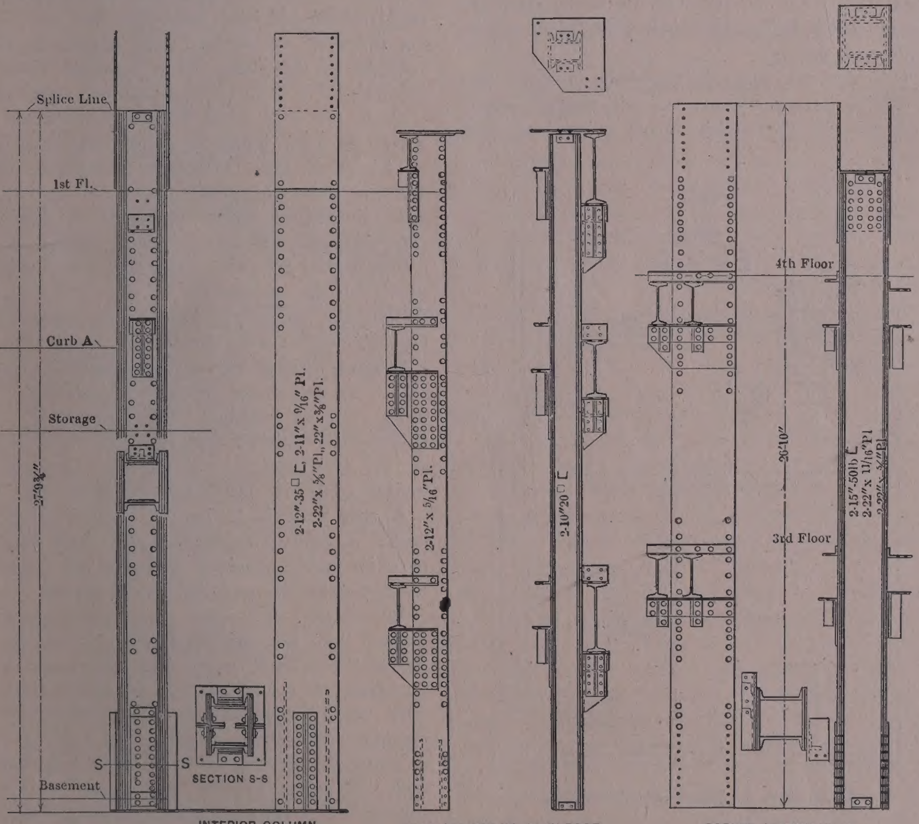
BRACING AT 22ND FLOOR FOR TERRA COTTA AT FRONT WALL COLUMNS

Miscellaneous Structural Details.

although it was generally necessary to hoist the material as fast as delivered so as not to obstruct traffic, and then deposit it on the upper tier of beams until it could be assembled in position, thus involving handling it twice in most cases.

All of the derricks were of standard design built by the contractors and equipped with Lidgerwood hoisting engines operated by General Electric motors and swung by hand levers. Three of them of 15 tons capacity, had 75-ft. masts from 18 to 20 in. in diameter and 68-ft. booms from 14 to 16 in. in diameter. They were guyed with six 1-in. galvanized iron lines. The fourth derrick was of 20 tons capacity and had a 65-ft. mast from 20 to 22 in. in diameter and a 57½-ft. boom from 16 to 20 in. in diameter and was guyed with seven 1¼-in. galvanized iron lines. The 15-ton derricks were rigged with two 2-part tackles rove with ⅝-in. steel line and the 20-ton derrick was rigged with two 3-part tackles.

At the beginning of operations a 30-ton derrick similar to the 20-ton derrick was set up at the ground level and was used for handling the heavy girders in the foundation work and in the first floor. It had a 75-ft. mast from 20 to 24 in. in diameter and a 68-ft. boom 20 in. in diameter at the butt, 22 in. in the middle and 18 in. at the tip and was rigged with two 3-part tackles rove with ⅝-in. steel line and was guyed with seven 1½-in. galvanized iron ropes.



INTERIOR COLUMN NO. 19

ROOF COLUMN NO. 32, IN ROOF

CORNER COLUMN NO. 1

Engineering Record

Typical Columns.

The 15 and 20-ton derricks were shifted every second story by a gang of ten men and were out of commission 3½ hr. on the average. The quickest record for shifting them was 2½ hr. This expedition was largely due to the special permanent attachments at the point of the boom by which six guy lines could be immediately connected with it and enable it to be used without loss of time as a jin pole for handling the mast. The 150,000 field rivets, ⅞ in. and 1 in. in diameter, were driven by seven Chicago Pneumatic Tool Co.'s hammers operated by a Franklin air compressor run by a 50-h.-p. General Electric motor fitted with an automatic cut-off and located in the next lot at the level of the basement floor.

Bricks, mortar, terra cotta, etc., were hoisted in three 2-barrow elevators running at a speed of 650 ft. per minute, and driven by hoisting engines designed by the contractors and operated by General Electric motors. Mortar was mixed in an electric driven machine manufactured by the Link-Belt Machinery Co., of Chicago, with a guaranteed capacity of 5 cu. yd. per hour. The concrete for the cellar floor 2½ ft. thick, and for the cellar walls was mixed by a Haines gravity mixer, which received the aggregate at the street level and delivered it in the cellar. The bricklayers worked on suspended platforms made by the Patent Scaffold Co., and operated by worm gears controlled by ropes from below.

The erection of the 6,000 tons of structural steel in the building was commenced in April and substantially completed June 15. The greatest progress was one story or 200 tons in 16 working hours. A maximum force of about 65 men was employed for the steel work, the total force on the roll at any one time was about 440 men, part of whom worked double time.

Clinton and Russell, New York, are the architects of the building, Col. J. H. Wells, engineer, and Mr. James Dougan, of their staff, assistant engineer. The Thompson-Starrett Co., Mr. George Simpson, chief engineer, is the general contractor, and prepared the detail drawings and the shop drawings of the steel work in accordance with the architects' requirements. Mr. Elmer E. Stewart is superintendent of erection for the contractor.

Large Reductions of Cost of Mining in Mexico have resulted from the use of electric power. In the El Oro mining camp electric power is received over a 200-mile transmission line at $50 gold, per horse-power per year, while the cost of steam power had previously been from three to four times that amount. This has reduced the cost of working the ore from $7 to $5 per ton.

Speed Control of Hydraulic Turbines.

At a meeting of the Philadelphia branch of the American Institute of Electrical Engineers, Mr. Lamar Lyndon presented a paper describing an electromagnetic method of regulating the speed of water wheels. The method is based primarily on changing rapidly the main gate opening of the wheel without altering either the pressure in the penstock or the velocity of the flow of water through the gate opening at the instant of change.

The control mechanism is so arranged that the velocity of the water in the penstock changes so slowly that there is never any appreciable fluctuation in the penstock pressure, or in the velocity of the entering water. There is applied to the penstock a compensating valve by means of which the pressure in the penstock is maintained. The compensating valve is of the butterfly type working in a by-pass pipe, which is tapped into the penstock.

All water which passes through the valve goes around the wheel and does no work. In plants where no waste can be allowed the valve is normally fully closed. If the turbine gate be quickly closed, the compensating valve will open quickly, thus acting as a positively operated relief valve. The valve then slowly closes tight, thus limiting the waste water to the ordinary relief valve losses.

In plants where the amount of water available is in excess of that passed through the turbine, the compensating valve is kept just half way open and a continual flow through it results. If the load on the turbine be increased, and the turbine gate be suddenly opened, the compensating valve will close, at the same speed, and thereby turn an increased amount of water into the turbine. If the load should decrease, the valve would open at once and allow more water to pass through it. In each case, when the regulation is completed for the new load, the compensating valve returns slowly to its normal half open position, thereby slowly changing the velocity of the water column to correspond to the supply required.

The active control mechanism consists of three electromagnetic clutches; one is used for opening the main turbine gate, the second tends to close the gate, while the third varies the opening of the compensating valve. When the gate openings are correct for the load on the machine, none of the clutches is energized. If the load increases or decreases, either the first or the second clutch comes into play, while the third operates to tend to close or open the compensating valve.

A diagram of the control circuits is shown in the accompanying illustration. Both the first and second clutches and a dynamo for supplying current to all of the clutches are driven from the turbine. The dynamo is a simple shunt-wound machine. It is provided with laminated field cores, so that the magnetism may respond quickly to changes in the magnetizing force, and is operated at low magnetic density, in order that the voltage may vary enormously with a change in the speed. The speed at which the dynamo must be driven in order to generate a certain electromagnetic force varies largely with the resistance in the field circuit, and this fact is utilized in adjusting the normal speed of the generator, and in giving to the turbine any desired load-speed characteristic.

The dynamo supplies current continuously to an electromagnet which serves to hold open the switches in the circuits to the three electromagnetic clutches when it possesses the proper strength, but allows the switch to the gate opening clutch to be closed by a spring if its strength is too small, and causes the switch to the closing clutch to be closed if its strength is too great.

The compensating valve is moved positively in a direction corresponding to the movement of the turbine gate by means of an electromagnetic clutch which is driven directly by the gate mechanism when either of the gate controlling electromagnets are energized, and is slowly returned to its normal position by means of a spring when the speed becomes normal and these clutches are idle.

Coal-Tar Paint.

While on the New Orleans Naval Station the attention of Mr. A. C. Cunningham, Civil Engineer, U. S. N., was frequently attracted by the fact that when the Southern Pacific steamers entered the port of New Orleans their hulls, from the water line for a considerable distance up, were painted with common coal tar. Further inquiry developed the information that coal tar was quite commonly used on the bottom of craft in the New Orleans section, and in the "Journal" of the American Society of Naval Engineers he gives some interesting information on the subject.

There is a general belief that the acids in coal tar are injurious to iron or steel, and a tradition that they can be neutralized by the addition of lime. The fact that raw coal tar is practically non-drying is well known.

Coal tar is used with great success in coating cast-iron pipe, most generally under the name of the Angus Smith Coating; in modern practice, however, this coating is really coal tar, thinned occasionally with linseed oil, when continued use makes the bath too viscous. The success of coal tar on cast-iron pipe is due to the fact that the iron is dipped into a warm bath and is at a black heat; these conditions drive off all the volatile matter and the tar becomes a lacquer. Pipe so coated will appear as fresh as new after being buried in the soil for years.

While the common coal tar was under observation and inquiry a patented coal-tar paint was offered for sale on the station at 50 cents per gallon; the paint had the appearance of a high-grade asphaltum paint. Examination of the formula by which the paint was made showed that it consisted of coal tar with some twenty different substances added in various proportions, evidently in no scientific manner, but after a cut and try method. The substances constituted two groups, one of which was a dryer and the other an acid neutralizer.

With this information as a basis and the tradition that lime would neutralize coal tar, a series of experiments were made to develop a paint, using turpentine as a dryer. The experiments were a failure. It was found that the lime, whether quick or slaked, spoiled the mixture, and the result was a non-lustrous coating of no durability.

In the next series of experiments Portland cement was substituted for lime, the turpentine still being used; an improvement in results was secured, but the paint was not entirely satisfactory. At this stage of the proceedings information was received that common kerosene oil would act as a dryer to coal tar, and another series of tests were started on this basis and the desired results were reached.

Since the writer left the New Orleans Naval Station the mixture has been applied to the bottom of the floating dry dock, and the next self-docking will give an idea of its value for under-water work.

The final mixture was tested by the Government chemist at the Washington Navy Yard, and pronounced non-injurious to iron and steel. The tests of the mixture were carried still further by the writer while stationed at the Naval Academy, and a perfected method of mixing developed.

The proportions of the mixture are slightly variable, according to the original consistency of the tar, the use for which intended, and the climate in which used. In general it will vary between the following proportions, by volume:

	Coal tar.	Portland cement.	Kerosene oil.
New Orleans mixture	8	1	1
Annapolis mixture	16	4	3

The Portland cement should be first carefully stirred into the kerosene oil forming a creamy mixture; this mixture is then carefully stirred into the coal tar. For the best results it should be freshly mixed and kept well stirred.

With this tar paint old leaky tin roofs at the Naval Academy, on buildings that were to be torn down in the course of two or three years, were made watertight; on the worst places a coat was applied, then muslin was stretched over the wet paint, and, after drying, an additional coat of paint applied over the muslin. Temporary sheds that were covered with tin taken from the demolished buildings had their roofs made water-tight and sightly.

This coal-tar paint is the only mixture that the writer has ever found that will unquestionably stick to and thoroughly cover galvanized iron.

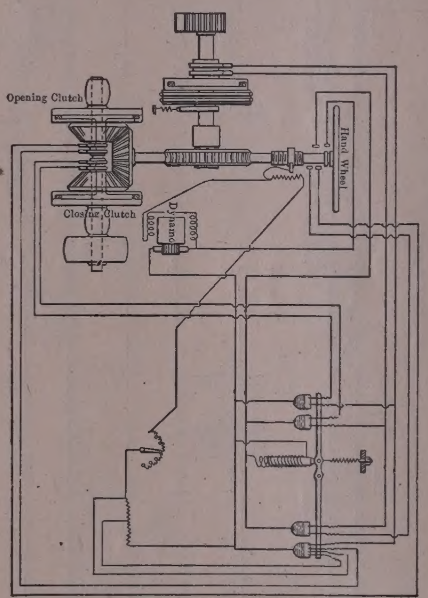


Diagram of Control Circuits.

The cost of this paint will vary from 10 to 15 cents per gallon, and when it is considered that even a fair linseed-oil paint will cost from 80 cents to $1 a gallon, the great economy is apparent. Linseed-oil paints have no durability in salt water or in a very salt atmosphere, on account of the solvent action between the salt and linseed oil. The tar paint, however, being composed of purely mineral materials, is quite stable and much more durable under the same conditions.

Red lead paint is an exception to the ordinary linseed-oil paints as regards durability. Ordinary oil paints dry by atmospheric oxidation from the outside in, assisted by the dryers or oxidizers that are added and whose ultimate effect is the shortening of the life of the paint. The red lead paint is dried by the oxidizing action of the red lead itself, and the resulting coat resembles to some extent an amalgam, and is very hard and durable.

After a series of experiments on the New Orleans floating dry dock the writer found the following proportions to give the best results in red lead paint:

Red lead, pounds	100
White zinc, pounds	20
Raw linseed oil, gallons	5
Turpentine Japan, pints	3¾

This should be used the same day that it is mixed, and if passed through a common hand mill after being mixed as well as possible by stirring, will be all the better.

For three-coat work on a clean, new surface the best results will be had by using 60 lb. of lead in the first coat, 80 lb. in the second, and 100 lb. in the last. The white zinc prevents the paint from crawling, and the raw oil is used on account of the intensely drying property of the red lead.

Boiled linseed oil is used in ordinary paints on account of its being already partially oxidized and thus drying more quickly.

The glaring red of red lead may be modified by the addition of a slight amount of lamp black without injury to the paint.

Ready-mixed red-lead paints are a snare and a delusion; true red lead paint will harden in a few hours in a vacuum, and in consequence a ready-mixed red-lead paint has had the oxidizing property of the red lead destroyed and is reduced to the status of a common linseed-oil paint.

True, red lead paint will cost from one and a half to two dollars a gallon, but if properly mixed from pure materials, carefully applied, and covered with a protecting coat of good common linseed-oil paint whenever it begins to show through will last for many years.

The purity of paint materials is a subject in itself, but as regards the coal-tar paint the materials are so inexpensive in themselves that no adulteration need be feared.

It goes without saying that a metallic surface that is to be painted should be as clean and free from scale as possible. New iron from a mill is generally painted too soon, as the mill scale is very tenacious for a long time, but will ultimately come off and bring the paint with it.

A rust scale is as bad to paint over as mill scale. A light newly-formed rust is not injurious to paint over, provided there is not too much for the paint to reach the metal proper.

The theory that when any rusted surface is painted over the oxidation will continue on into the metal without extraneous assistance, is, on the face of it, erroneous, as iron oxide is a very stable combination. The conditions for rusting require the presence of both air and moisture; in dry air or pure water iron will not rust. Painting over a rust scale insures the contact of a porous layer containing both air and moisture against the pure metal, and rust scales continue to form under the most favorable conditions until the swelling of the oxide causes the whole to fall off. The black surface which then appears is sometimes mistaken for the mill surface of the metal.

The writer makes no unusual claims for coal-tar paint, but believes that it is better than most cheap paints of unknown origin and materials. It has been sufficiently demonstrated that it is of some value, its low cost is attractive, and in emergencies it might be of great use.

A Motor-Driven Rail Mill is now in operation at the Edgar Thompson plant of the Carnegie Steel Co. at Bessemer, Pa. It is equipped with two 1,500-h.-p., 30-pole, 220-volt, direct-current motors overcompounded 15 per cent., which operate at from 100 to 125 r.p.m. Each motor carries a 125,000-lb. cast-steel segmental fly-wheel which frees the motor from the extreme shocks of rolling. The power delivered by each motor ranges from 950 to 1,450 h.-p. in rolling rails with occasional jumps to 1,700 h.-p., while the friction load on the mill running light is about 500 h.-p.